7

Surface Water

Erich R. Brandstetter
Karen J. Folks
Shari L. Brigdon
Robert J. Vellinger

Introduction

Lawrence Livermore National Laboratory (LLNL) monitors surface water at the Livermore site, in surrounding regions of the Livermore Valley, and at Site 300 and vicinity in the nearby Altamont Hills. At the first two locales, LLNL monitors reservoirs and ponds, the Livermore site swimming pool, the Drainage Retention Basin (DRB), treated ground water discharges, rainfall, tap water, and storm water runoff. At Site 300 and vicinity, surface water monitoring encompasses rainfall, cooling tower discharges, and storm water runoff. The water samples are analyzed for radionuclides, high explosives, total organic carbon, total organic halides, total suspended solids, conductivity, pH, chemical oxygen demand, total dissolved solids, oil and grease, metals, minerals, anions, and a wide range of organic compounds. In addition, fish bioassays are performed annually on water entering and leaving the Livermore site via the Arroyo Las Positas pathway, discharges from the DRB, and water contained in the DRB.

Storm Water

Storm water (runoff water) monitoring is driven by the requirements in the *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (U.S. Department of Energy 1991); DOE Orders 5400.1, General Environmental Protection Program, and 5400.5, Radiation Protection of the Public and the Environment; and two National Pollutant Discharge Elimination System (NPDES) permits issued under the authority of the Federal Clean Water Act and the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Record of Decision (ROD).

Storm water comes in contact with a large number of potential pollution sources and has the potential to disperse contaminants across broad areas. To evaluate the overall impact of Livermore site and Site 300 operations on storm water quality, storm water flows are sampled where they leave the site. These samples provide information used to evaluate the effectiveness of LLNL's storm water pollution control program. The

NPDES permits for storm water (WDR Order No. 95-174, NPDES Permit No. CA0030023 for the Livermore site and WDR Order No. 94-131, NPDES Permit No. CA0081396 for Site 300) require that LLNL conduct effluent sampling and visual inspections of the storm drainage system monthly during the wet season, whenever significant storms occur, and twice during the dry season to identify any dry weather flows. In addition, annual facility inspections are required to assure that the necessary management measures are adequate and implemented. The goals of the storm water monitoring program are to demonstrate compliance with permit requirements, aid in implementing the Storm Water Pollution Prevention Plan (SWPPP) (Eccher 1994), and measure the effectiveness of the best management practices (BMPs) in preventing contamination of storm water discharges.

LLNL first monitored storm water runoff at the Livermore site in 1975. The original monitoring network, designed to detect pesticides, was expanded in 1990 to cover new locations and additional water quality parameters (i.e., radioactivity, metals, and additional organic compounds). Additional changes during 1993 complied with the National Pollutant Discharge Elimination System General Industrial Activities Storm Water Permit (NPDES General Permit). In October 1993, also in response to the NPDES General Permit, LLNL established a new storm water monitoring program at Site 300. In 1995, the San Francisco Bay Region Water Quality Control Board (RWQCB) issued a Waste Discharge Requirements and National Pollutant Discharge Elimination System Permit (NPDES No. CA0030023, WDR 95-174) for the Livermore site, which replaced coverage under the Statewide General NPDES Permit for Storm Water Discharges Associated with Industrial Activities (Order No. 91-13-DWQ). The new permit includes specific monitoring and reporting requirements. The current list of analyses requested for storm water samples is given in **Table 7-1**. Flow patterns at the site are such that storm water at sampling locations includes components from other sources, such as neighboring agricultural land, parking lots, and landscaped areas. Because of this, and because wide-ranging activities are conducted at the Livermore site, it is necessary to analyze storm water for a wide variety of constituents at the Livermore site. In contrast, storm water at Site 300 is sampled at locations that target specific activities, and a smaller range of analyses is sufficient.

Currently, there are no numerical criteria that limit concentrations of specific constituents in storm water effluent. In the federal multisector permit, the Environmental Protection Agency (EPA) established benchmark values for 41 parameters but stressed that these concentrations were not intended to be interpreted as effluent limitations (see **Table 7-2**). Rather, they are levels that the EPA has used to determine if storm water discharged from any given facility merits further monitoring. Other water quality criteria developed by California and the federal

Table 7-1. Requested analyses for storm water samples, 1996.

Livermore site	Site 300
pH	pH
Total suspended solids	Total suspended solids
Specific conductance	Specific conductance
Oil and grease	Total organic carbon
Total organic carbon	Gross alpha and beta
Gross alpha and beta	Tritium
Tritium	Uranium
Chemical oxygen demand	Total organic halides
General minerals	Explosives
Anions	
Metals	
Herbicides—EPA Method 507	
Glycophosphate—EPA Method 547	
Diuron—EPA Method 632	
Fish bioassay (fathead minnow)	

government were used as comparisons with LLNL storm water analysis results in this report. However, these criteria are defined for other purposes, and are therefore not directly applicable to storm water effluent. Nevertheless, use of a broad range of criteria can help to evaluate LLNL's storm water management program and to allow LLNL to ensure high quality in its storm water effluent.

Storm water sample results for the Livermore site were compared with criteria listed in the *Water Quality Control Plan, San Francisco Bay Basin Region* (San Francisco Bay RWQCB 1995), and results for Site 300 were compared with criteria listed in *The Water Quality Control Plan* (*Basin Plan)* for the California Central Valley RWQCB (Longley et al. 1994). Criteria in the Basin Plans include surface water quality objectives for the protection of aquatic life and water quality objectives for waters designated for use as domestic or municipal supply or agricultural supply. These criteria include, by reference, California Maximum Contaminant Levels (MCLs) for drinking water. In addition, results were compared with EPA MCLs and ambient water quality criteria (AWQC), as well as California AWQC. Criteria not specifically listed in the Basin Plans were obtained from *A Compilation of Water Quality Goals* (Marshack 1995). Criteria are summarized in **Table 7-2**.

Table 7-2. Storm water nonradioactive comparison criteria, Livermore site, 1996.

Parameter	MCL[a]	AWQC[b]	Benchmark
Materials (mg/L)			
Aluminum	1 (CA)	0.75	0.75
Antimony	0.006 (EPA)	0.088	0.636
Barium	1 (CA)	none	none
Chemical oxygen demand	none	none	120
Chloride	250 (EPA)	860	860
Chromium	0.05 (CA)	0.016[c]	none
Copper	1 (EPA)	0.027	0.063
Fluoride	1.4 (CA)	none	1.8
Chromium(VI)	0.05 (CA)	0.015	none
Iron	0.3 (EPA)	1	1
Lead	0.015 (EPA)	0.11	0.0816
Manganese	0.5 (EPA)	none	1
Nickel	0.1 (EPA)	2.15	1.417
Oil and grease	none	none	15
Ortho-phosphate	none	none	2[d]
Thallium	0.002 (EPA)	none	none
Total alkalinity (as $CaCO_3$)	none (EPA)	20	none
Total dissolved solids (TDS)	500 (CA)	none	
Total suspended solids (TSS)	none	none	100
Vanadium	none	none	none
Zinc	5 (EPA)	0.175	0.117
General indicator parameters			
pH	6.5-8.5 (EPA)	6.5-9	6-9
Specific conductance (μmho/cm)	900 (CA)	none	none
EPA Method 507 (μg/L)			
Simazine	4 (EPA)	none	none
EPA Method 615 (μg/L)			
2,4-D	70 (EPA)	none	none
EPA Method 625 (μg/L)			
Bis(2-ethylhexyl)phthalate	4 (CA)	400	none

a MCL = Maximum contaminant level.

b AWQC = Ambient water quality criteria.

c Assumes Cr(VI).

d Total phosphorous.

Although before 1995 Arroyo Las Positas only flowed when it rained, dry weather observations at the Livermore site noted that water flowed in Arroyo Las Positas throughout 1996. This water originated from two sources: natural flow of water from off site that entered LLNL property at the ALPO influent location (**Figure 7-1**), and permitted discharges from ground water treatment facilities. Dry weather inspections at Site 300 showed no indication of nonpermitted nonstorm water flows discharging from the site.

Each LLNL directorate inspected its facilities to verify that the best management practices (BMPs) identified in LLNL's Storm Water Pollution Prevention Plans (SWPPPs) were in place, properly implemented, and adequate. LLNL implements BMPs at construction sites and at facilities that use significant materials (as defined by the storm water regulations) to prevent storm water from being contaminated. The results of the inspections indicated that LLNL facilities were in compliance with the requirements of the SWPPPs and the provisions of the NPDES permits. LLNL submits annual storm water monitoring reports to the San Francisco Bay RWQCB and the Central Valley RWQCB reporting the results of sampling, observations, and inspections.

LLNL also meets the storm water compliance monitoring requirements authorized under the California General Construction Activity Storm Water Permit for construction projects disturbing 2 hectares of land or more. Monitoring for these construction projects included visual observation of sites before and after storms to assess the effectiveness of implemented BMPs. Three Livermore construction sites were inspected during 1996: Building 132; the DWTF project area; and the areas associated with the beneficial reuse of soils in the North Buffer Zone Regrading Project and landscaping throughout the developed areas of the Livermore site. As required by the California General Construction Activity Storm Water Permit, the construction managers annually certify compliance with the specific project SWPPP and the requirements of this general permit.

These projects were in compliance with their SWPPPs except for one grading project associated with the North Buffer Zone. Regrading was not inspected after May 17, 1996, rainfall, and the post-stabilization inspection was not documented. The project SWPPP was subsequently amended to augment the inspection requirements and an inspection checklist was developed. The DWTF construction project SWPPP was amended to address road cleaning. For the first time in 1996, the San Francisco Bay RWQCB requested the submission of Construction Status Compliance reports for the three construction projects at the Livermore site.

Livermore Site

The natural drainage at the Livermore site was altered by construction activities several times up to 1966 (Thorpe et al. 1990) so that the current northwest flow of Arroyo Seco

and the north-then-west flow of Arroyo Las Positas do not represent historical flow paths. About 1.6 km to the west of the Livermore site, Arroyo Seco merges with Arroyo Las Positas, which continues to the west to eventually merge with Arroyo Mocho. An abandoned stream channel is visible on air-photo maps of the site east of the present alignment of Arroyo Seco (Carpenter et al. 1984). A drainage retention basin (DRB) for storm water diversion and flood control was excavated and constructed to the north and west of Building 551 and collects about one fourth of the surface water runoff from the site and a portion of the Arroyo Las Positas drainage (**Figure 7-1**). This basin was lined in 1990 to prevent infiltration in this area.

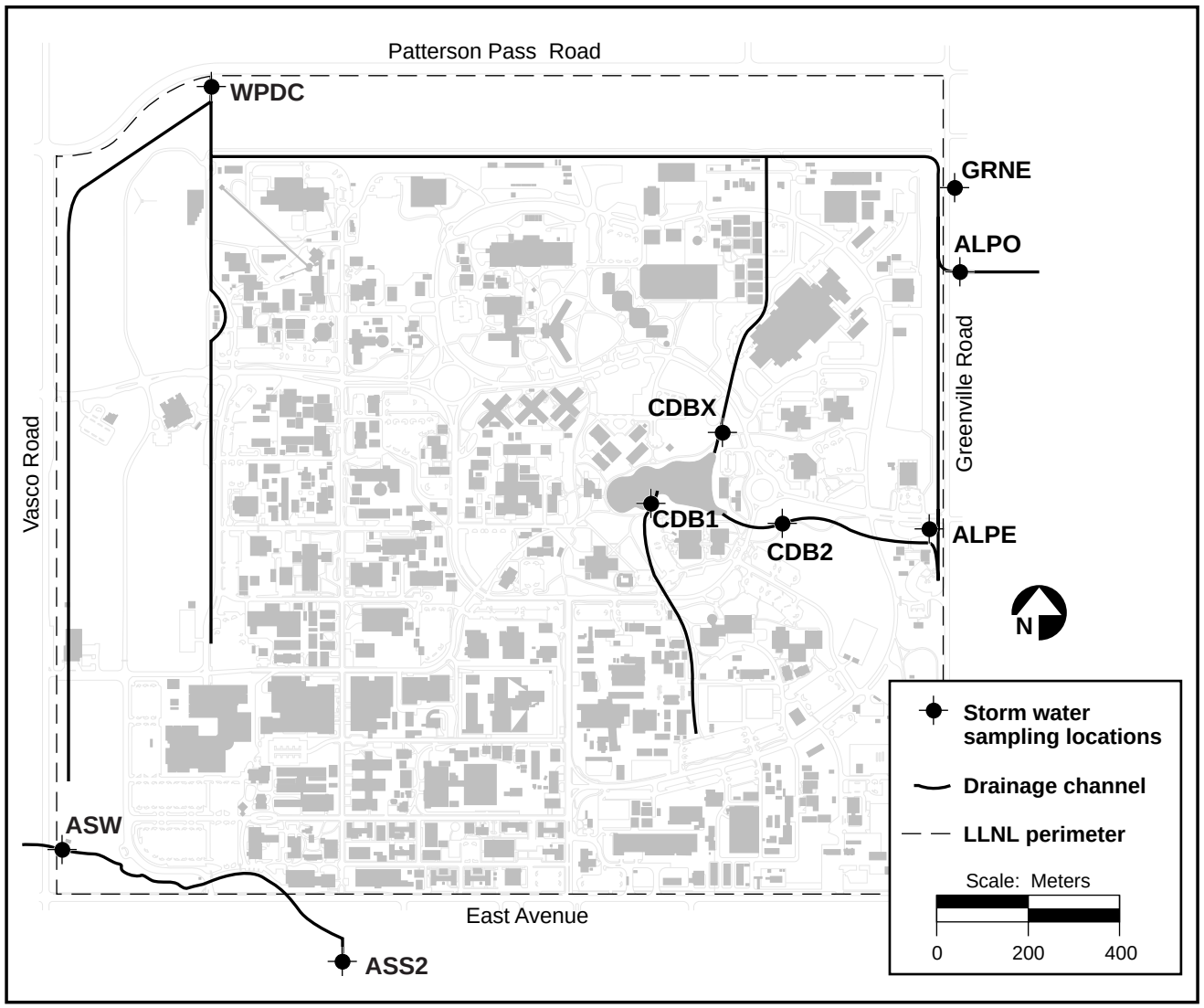

Figure 7-1. Storm water runoff sampling locations, Livermore site and vicinity, 1996.

The DRB discharges to a culvert that leads to Arroyo Las Positas. The remainder of the site drains either directly or eventually into two arroyos by way of storm sewers and ditches. The two arroyos drain from east to west. Arroyo Seco cuts across the southwestern corner of the site. Arroyo Las Positas, diverted from its natural course, follows the northeastern and northern boundaries of the site and exits the site at the northwest corner.

In 1996, the Livermore site storm water sampling network consisted of nine locations (**Figure 7-1**). Six locations characterize storm water either entering (influent: ALPE, ALPO, GRNE, and ASS2) or exiting (effluent: WPDC and ASW) the Livermore site. Locations CDB and CDB2 characterize runoff from the southeastern quadrant of the Livermore site entering the DRB, and location CDBX characterizes water leaving the DRB.

Historically, LLNL has analyzed storm water for a wide range of organic constituents. A review of recent data (1991–1996), however, showed that no organic constituent specifically identified was detected in more than 25% of the samples. The most commonly detected organic constituents were acetone, in 6 out of 49 samples (12%), bis(2-ethylhexyl)phthalate (4 detections, or 8%), and Freon 113 (3 detections, or 6%). All other organic constituents specifically identified were detected only once or twice in the 49 sampling events. Therefore, starting in the fall of 1996, organic analyses were selected to target pesticides known to be used at the Livermore site. Organic analyses now conducted are EPA 507 (herbicides), EPA 547 (glycophosphate), and EPA 632 (diuron).

LLNL collected storm water samples from four storm events in 1996. Samples were collected at all Livermore site locations on January 16, April 1, May 15, and October 29, 1996.

As required by LLNL's NPDES permit (WDR 95-174, NPDES No. CA0030023), LLNL conducted an annual fish bioassay. In this acute toxicity test, 96-hour survival of fathead minnow (*Pimephales promelas*) in undiluted storm water collected from effluent location WPDC is observed. The Regional Board has set a criteria of 20% survival compared with the control as an acceptable level. The testing laboratory provides water to use in the control sample. In addition, in agreement with Regional Board guidance, upgradient waters from influent locations ALPO, ALPE, and GRNE are used as added controls. Thus, a difference of more than 20% between location WPDC and the control sample with the lowest survival is considered a failed test. For example, if survival in the laboratory control is 95%, and survival in water from ALPO, ALPE, and GRNE is 80%, 75%, and 85%, respectively, then survival of less than 55% in WPDC water would be a failed test. If the test is failed, LLNL is

required to sample the next runoff event. If two consecutive tests are failed, LLNL is required to perform a toxicity reduction evaluation to identify the source of the toxicity. In this year's acute toxicity test, 95% of the minnows survived in the WPDC water. The survival rate in GRNE water was also 95%, while the survival rate in ALPO, ALPE and the laboratory control water was 100%.

Storm water gross alpha, gross beta, and tritium results are summarized in **Table 7-3**. Median activities were less than 10% of the respective MCLs. **Figures 7-2** and **7-3** show the historical trend in storm water gross alpha and gross beta, respectively. In these and other storm water historical trend figures in this chapter, all available data for the influent and effluent locations of the two runoff pathways through the Livermore site have been aggregated. Also, data have been aggregated on a wet season basis—that is, October of one year through May of the next—rather than on a calendar year basis. Thus, data on storm plots labeled 95/96 represent October 1995 through May 1996, and data labeled 96 represent October through December 1996. The 1996 points represent a partial wet season, pending collection of 1997 data, and are based on only one sampling event for each location. Finally, plots include all available storm water influent and effluent data for each constituent. The gross alpha and gross beta data show no discernible pattern. The historical trend in tritium levels (**Figure 7-4**), which correlates with decreased emissions (see Chapter 5), indicates generally decreasing tritium levels in storm water from the 1988–89 to 1991–92 season, after which the curve is relatively flat.

Table 7-3. Radioactivity (in Bq/L) in storm water runoff, Livermore site, 1996.

	Tritium	Gross alpha	Gross beta
Median	2.23	0.056	0.16
Minimum	<1.64	<0.02	<0.06
Maximum	139.12	0.47	0.68
Interquartile range	4.06	0.050	0.11
Maximum contaminant level (MCL)	740	0.56	1.85

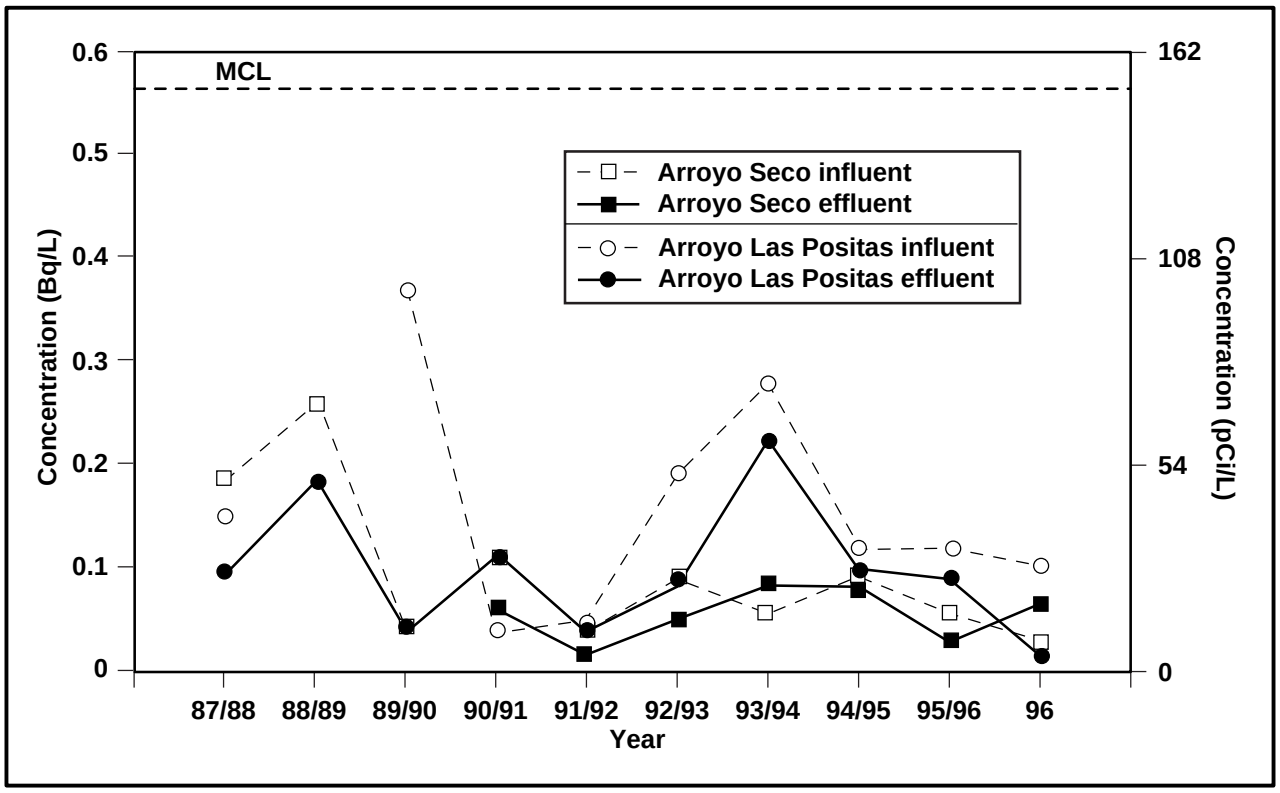

Figure 7-2. Annual median gross alpha in LLNL storm water compared with the maximum contaminant level (MCL).

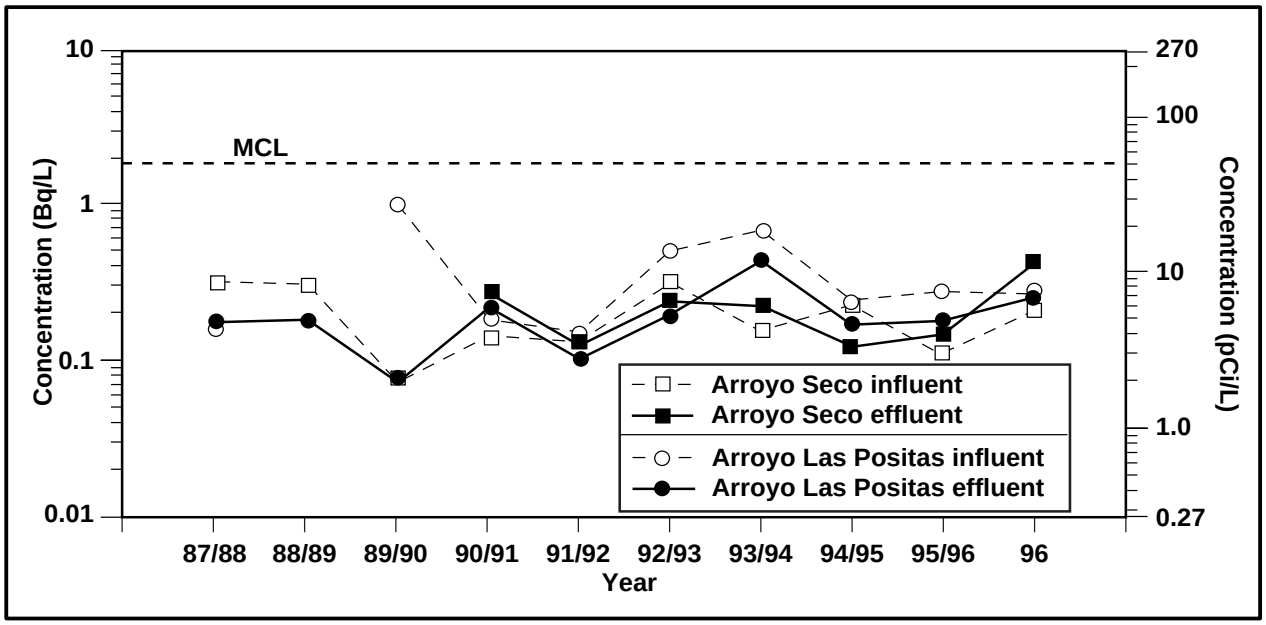

Figure 7-3. Annual median gross beta in LLNL storm water compared with the maximum contaminant level (MCL).

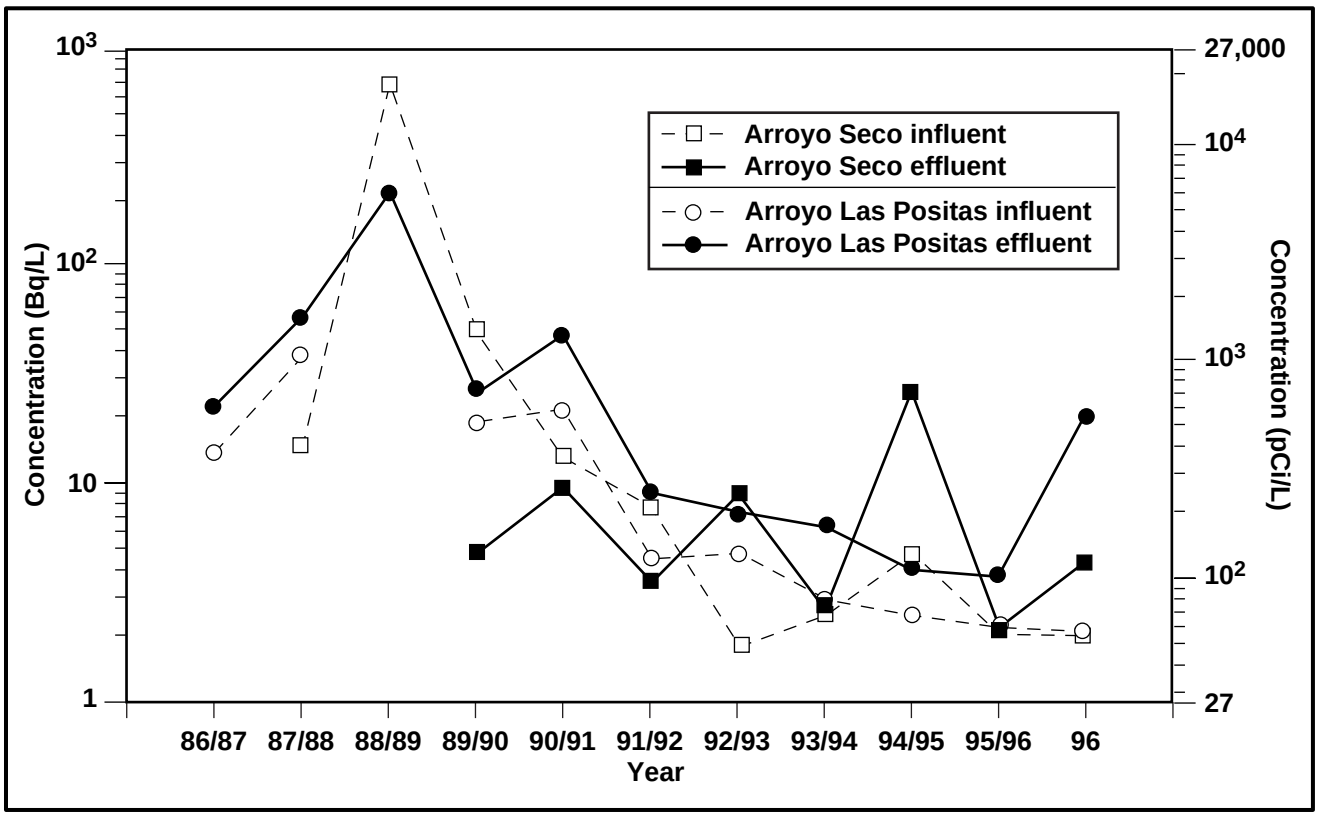

Figure 7-4. Annual median tritium concentrations in LLNL storm water.

Table 7-4 lists nonradioactive constituents found above comparison criteria in Livermore site storm water. Complete storm water results are presented in Table 7-2, Volume 2. Of greatest concern are constituents that exceeded comparison criteria at effluent points, but for which the influent concentrations were less than the corresponding effluent concentrations. This was the case for aluminum, chromium, copper, iron, manganese, nickel, and zinc. Historical trend plots seem to indicate that many of these constituents, for example, chromium, copper, and zinc, are increasing over time (**Figures 7-5, 7-6,** and **7-7**). However, review of the data indicates that the apparent increases are primarily due to a shift from analyses that only recover dissolved metals to analyses that recover the total metal concentrations in the water (dissolved plus suspended). Next year, investigations are planned to determine how much of these metals are present in the liquid and how much in sediments being transported, for example, during high flow events.

Table 7-4. Nonradioactive constituents above comparison criteria in storm water runoff, Livermore site, 1996.

Parameter	Storm date	ALPE	ALPO	ASS2	ASW	CDB	CDB2	GRNE	WPDC
Materials (mg/L)									
Aluminum	1/16			0.87					1.7
	4/1	73	7.3	9.2	8.1	6.4	52	29	32
	4/1	65	6.2	8.7	8.8	8.6	38	28	31
	5/15	10	5.4	5.7	4.2	5.4	8.9	14	33
	10/29	3.1	5.5	5.6	13	4.4	4.6	36	5.4
	10/29	4.7	4.4	3.6	20	5.1	5.2	82	2.5
Antimony	5/15						0.013		
Barium	10/29							1.2	
Chemical oxygen demand	10/29	276			419	262	150		190
Chloride	4/1		300						
	4/1		300						
Chromium	1/16	0.062				0.018	0.019		0.022
	4/1	0.16		0.02	0.018	0.017	0.11	0.065	0.065
	5/15	0.029					0.026		0.062
	10/29				0.059	0.02	0.022	0.18	
Copper	4/1	0.081					0.063	0.037	0.042
	4/1	0.082					0.049	0.028	0.035
	5/15				0.031		0.044		0.054
	10/29				0.64	0.043	0.03	0.037	0.035
	10/29					0.045	0.039	0.086	0.037
Fluoride	4/1		1.7						
	4/1		1.7						
	10/29		0.84						
Chromium(VI)	1/16	0.093							
Iron	1/16	24	7	1.8	2.3	7.6	5.9	6.1	9.7
	1/16			0.63	0.4	0.43	0.43		0.44
	4/1	78	5.6	8.2	7.1	5.5	45	27	26
	4/1	72	5.4	8.3	7.6	7.3	38	26	27
	5/15	11	4.1	6.1	4.8	5.3	7.8	10	30
	5/15					0.69			
	10/29	4.3	4.9	7	15	5.3	5	37	6.2
	10/29	5.7	4.1	4.6	24	6.2	5.8	84	3
Lead	5/15	0.016					0.021		

Table 7-4. Nonradioactive constituents above comparison criteria in storm water runoff, Livermore site, 1996 (continued).

Parameter	Storm date	ALPE	ALPO	ASS2	ASW	CDB	CDB2	GRNE	WPDC
Manganese	1/16	0.44	0.17		0.036	0.15	0.09	0.093	0.18
	4/1	1.7	0.15	0.17	0.13	0.11	0.85	0.58	0.45
	4/1	1.6	0.13	0.17	0.14	0.15	0.75	0.55	0.46
	5/15	0.25	0.091	0.14	0.12	0.18	0.2	0.17	0.6
	5/15	0.078	0.078	0.048	0.069	0.19	0.12		0.14
	10/29	0.31	0.13	0.19	0.51	0.37	0.18	0.72	0.28
	10/29	0.32	0.12	0.15	0.64	0.37	0.22	1.9	0.31
Nickel	4/1	0.18	0.15				0.12	0.49	0.6
	4/1	0.16							
	10/29							0.19	
Oil and grease	1/16						24		
Orthophosphate	10/29				2.7				
	10/29				2.7				
Thallium	10/29							0.0024	
Total alkalinity (as $CaCO_3$)	1/16			15		7.5	14		
	4/1			9		8	14		
	5/15					1	19		
	10/29			9.9			14.2		
	10/29			11.3		19.9	13.5		
Total dissolved solids (TDS)	1/16	800	340	59	47	64	68	100	140
	4/1	120	1100	70	50	60	60	90	190
	5/15	110	190	94	81	92	130	150	150
	10/29	220	775	62	290	195	102	74	280
Total suspended solids (TSS)	4/1	500	230	130	150	340	440	380	650
	5/15	540	640	660	220	1300	1100	700	620
	10/29	143	161	296	480	120	186	2160	
Vanadium	4/1	0.17					0.11		
	10/29							0.18	
Zinc	1/16								0.13
	4/1	0.39		0.27			0.25	0.16	0.26
	4/1	0.37		0.28			0.21	0.15	0.26
	5/15			0.24	0.16	0.26	0.29		0.6
	5/15			0.52	0.13	0.35	0.23		1.1
	10/29	0.16		0.45	0.31	0.9	0.34		0.4
	10/29	0.17		0.38	0.35	0.9	0.42	0.25	0.58

Table 7-4. Nonradioactive constituents above comparison criteria in storm water runoff, Livermore site, 1996 (concluded).

Parameter	Storm date	ALPE	ALPO	ASS2	ASW	CDB	CDB2	GRNE	WPDC
General indicator parameters									
pH	1/16								
	4/1								
	5/15			6.2	5.9	5.6	5.8		
	10/29				6.44	6.13			
Specific conductance (μmho/cm)	1/16	1200							
	4/1		1800						
	10/29		1210						
EPA Method 507 (μg/L)									
Simazine	10/29				9.3				
EPA Method 615 (μg/L)									
2,4-D	4/1							72	
EPA Method 625 (μg/L)									
Bis(2-ethylhexyl)phthalate	5/15			5.2					

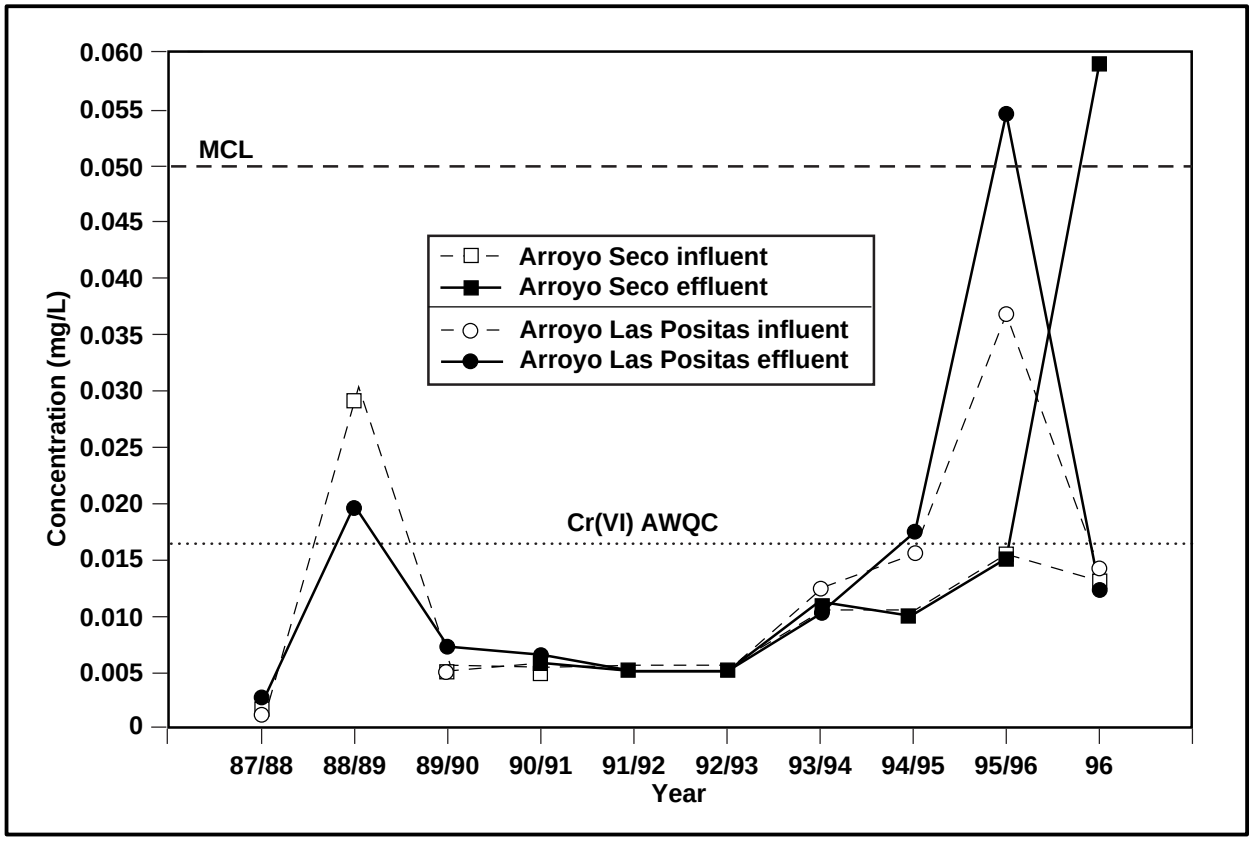

Figure 7-5. Chromium in LLNL storm water, compared with the maximum contaminant level (MCL) and ambient water quality criterion (AWQC) values.

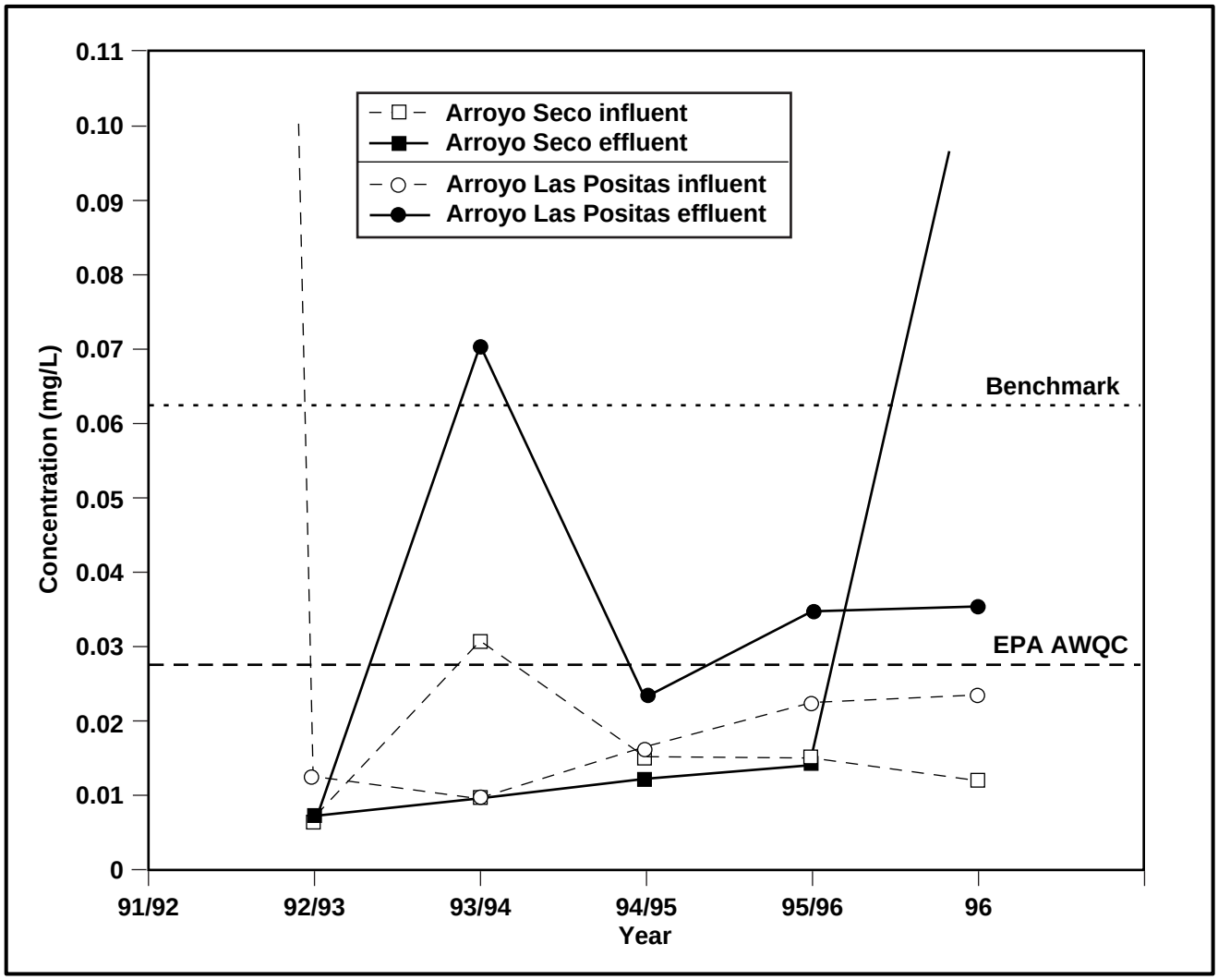

Figure 7-6. Annual median gross copper in LLNL storm water compared with the benchmark and ambient water quality criterion (AWQC) values. The concentration of copper in Arroyo Las Positas influent in 1991–92 was 0.97 mg/L. In 1996–97, the copper concentration in Arroyo Seco effluent was 0.385 mg/L. Both values are off the concentration scale in this figure.

Chromium, copper, and zinc are common constituents in urban runoff (Salomons et al. 1995). All three elements have been linked with automobile metal corrosion and emissions; copper and zinc concentrations have been correlated with traffic volume, and one study showed a zinc concentration of 0.37 mg/L in highway runoff. In addition, zinc is released from automobile tires (Salomons et al. 1995). Thus, it is likely that these types of nonindustrial sources are contributing metals to storm water runoff at the Livermore site.

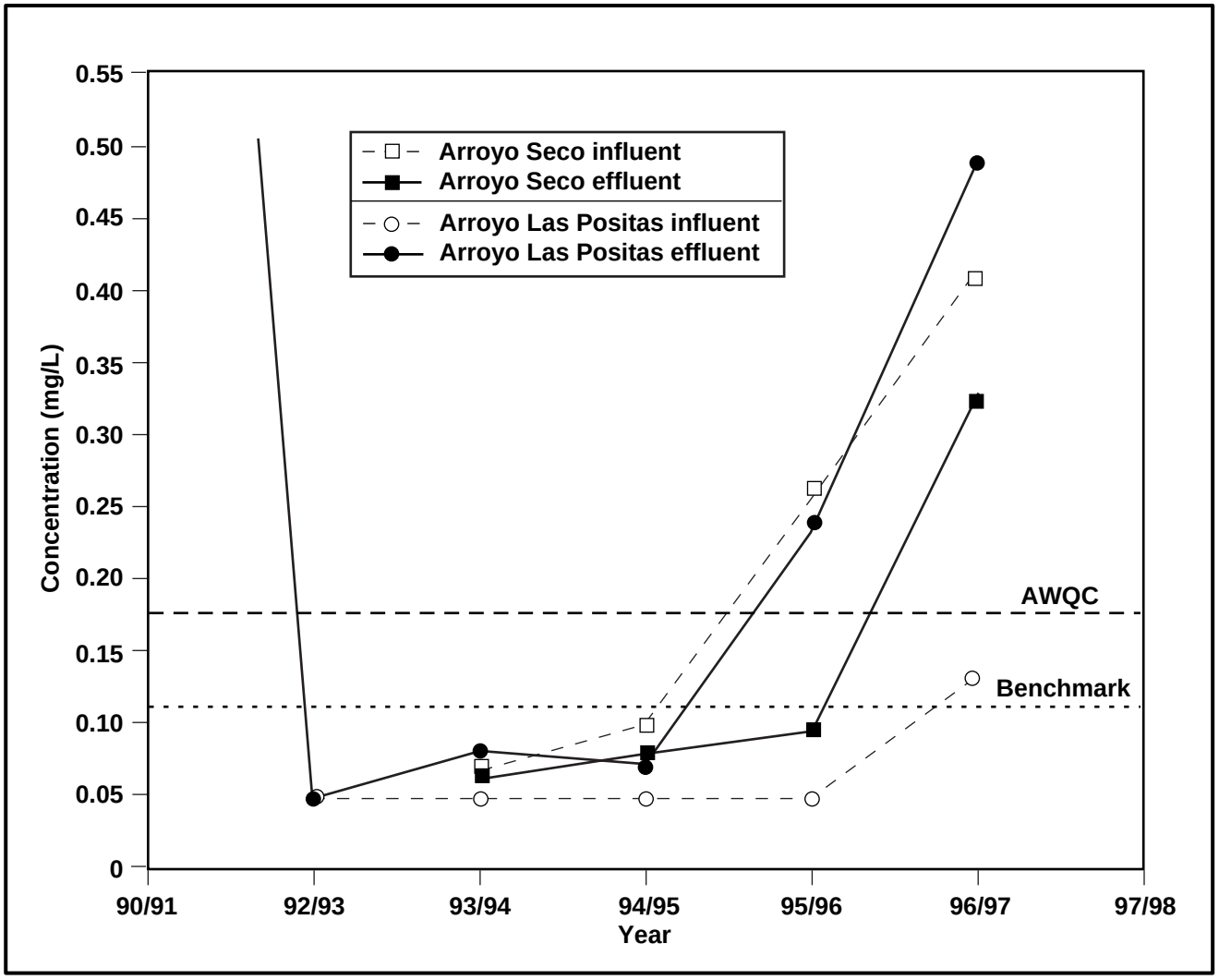

Figure 7-7. Annual median zinc concentrations in LLNL storm water compared with the benchmark and ambient water criterion (AWQC) values. The concentration of zinc in Arroyo Las Positas effluent in 1991–92 was 1.5 mg/L, which is off the concentration scale in this figure.

Other constituents found (from 1–3 times) above comparison criteria at effluent points, and above the corresponding influent points, were total dissolved solids, total suspended solids, and the pesticide Simazine. In addition, two samples taken at the effluent point had pH values that were lower than the secondary MCL minimum pH. The pH values of both samples were lower than pH values of samples taken at the influent point.

A number of other constituents in LLNL runoff were also above comparison criteria. In every case, however, when the concentration exceeded a criterion at an effluent point,

there was a corresponding influent point with a higher concentration, indicating an off-site or possibly naturally occurring source. These constituents were antimony, barium, chemical oxygen demand, chloride, fluoride, hexavalent chromium, lead, oil and grease, ortho-phosphate, thallium, total alkalinity, specific conductance, vanadium, bis(2-ethylhexyl)phthalate, and 2,4-D (2,4-dichlorophenoxy acetic acid). Bromocil was the only other organic constituent detected in 1996 storm water runoff.

Site 300

The topography of Site 300 is much more irregular than that of the Livermore site; steep hills and ridges oriented along a generally northwest/southeast trend are separated by intervening ravines. The elevation ranges from approximately 150 m above sea level at the southeast corner of the site to approximately 538 m in the northwestern portion.

Surface water at Site 300 consists of seasonal stream runoff, springs, and natural and man-made ponds. Surface water sometimes occurs locally as a result of building discharges. The primary drainage in the Site 300 area is Corral Hollow Creek, an ephemeral stream that borders the site to the south and southeast. No continuously flowing streams are present in the Site 300 area. Elk Ravine is the major drainageway for most of Site 300; it extends from the northwest portion of the site to the east-central area. Corral Hollow and Elk Ravine drain eastward to the San Joaquin River Basin. Some smaller canyons in the northeast portion of the site drain to the north and east toward Tracy. A small portion of Site 300 drains to Alameda County, but is not included in the storm water sampling because there are no industrial activities in the associated drainages.

There are at least 23 springs at Site 300. Nineteen are perennial, and four are intermittent. Most of the springs have very low flow rates and are recognized only by small marshy areas, pools of water, or vegetation. Vegetation surrounding the springs includes cattails, nettles, willows, and grass. Only three of the springs have flow rates greater than 4 L/min. The significance of individual springs is discussed in the *Final Site-Wide Remedial Investigation Report, Lawrence Livermore National Laboratory Site 300*, hereafter referred to as the Final SWRI Report (Webster-Scholten 1994). A vernal pool is present in the northwest corner of Site 300. It is a perennial pool created by ponding of water in a natural depression.

Three artificial surface water bodies are present at Site 300. A sewage treatment pond is located in the southeast corner of the site in the General Services Area (GSA), and two lined High Explosives (HE) rinse water impoundments are located to the west in the Explosives Process Area. A residence pond at the Carnegie State Vehicular Recreation Area is located off site just east of Pit 6 at the mouth of Middle Canyon. In addition, four small off-site stock watering ponds are present in the area north of Site 300.

Other surface water at Site 300 results from blowdown water from cooling towers in the East and West Firing Areas and other areas. Cooling tower discharges and their potential impact are discussed in the Final SWRI Report (Webster-Scholten 1994).

The Site 300 storm water sampling network began in 1994 with six locations and expanded to eight locations in 1995 (**Figure 7-8**). Location CARW was added to further characterize background conditions in Corral Hollow Creek, along with existing location NSTN. Location GEOCRK was formerly reported in Chapter 8 (which discusses ground water monitoring) because an upgradient spring contributes water representative of ground water. GEOCRK was transferred to storm water monitoring in order to utilize the location to characterize runoff in Corral Hollow Creek, downgradient of Site 300. The remaining five locations were selected to characterize storm water runoff at locations that could potentially be affected by specific Site 300 activities.

Samples were collected from some Site 300 locations on January 16, January 31, March 13, May 15, and October 29, 1996. Typically, a given storm will not produce runoff at all Site 300 locations because Site 300 receives relatively little rainfall and is largely undeveloped. Therefore, at many locations, a series of large storms is required to saturate the ground before runoff occurs.

The maximum tritium concentration in Site 300 storm water was 2.47 Bq/L (66.7 pCi/L), or 0.3 % of the 740 Bq/L (20,000 pCi/L) MCL (**Table 7-5**). Gross alpha was above its MCL (0.56 Bq/L or 15 pCi/L) on January 31 at background locations CARW and NSTN, at on-site location NLIN, and at downgradient location GEOCRK; and on January 16 at location NPT6. In addition, on January 16, gross beta was above its MCL (1.85 Bq/L, or 50 pCi/L) at location NPT6. The highest gross alpha and gross beta were at NPT6 on January 16, 4.26 and 7.55 Bq/L (115 and 204 pCi/L), respectively. Past studies, reported in Chapter 7 of the *Environmental Report 1995* (Harrach et al. 1996), of storm water samples with high gross alpha and gross beta levels have shown that the apparent high levels of gross alpha and gross beta radiation were caused by high sediment loads (due to erosion typical of the region) and naturally occurring levels of potassium, thorium, and uranium, along with their daughter products, carried in that sediment. Furthermore, the gross alpha and gross beta in the solid phase were at background levels. A plot of sediment load vs gross alpha and gross beta radiation showed a clear relationship, and the 1996 high gross alpha and gross beta results follow the same pattern (**Figure 7-9**). Thus, these samples do not indicate that some new source has contributed to increased environmental gross alpha and gross beta radiation, but rather, only that more sediments are being transported in these storm events at these locations. There is no indication of an anthropogenic source of the gross alpha and gross beta levels.

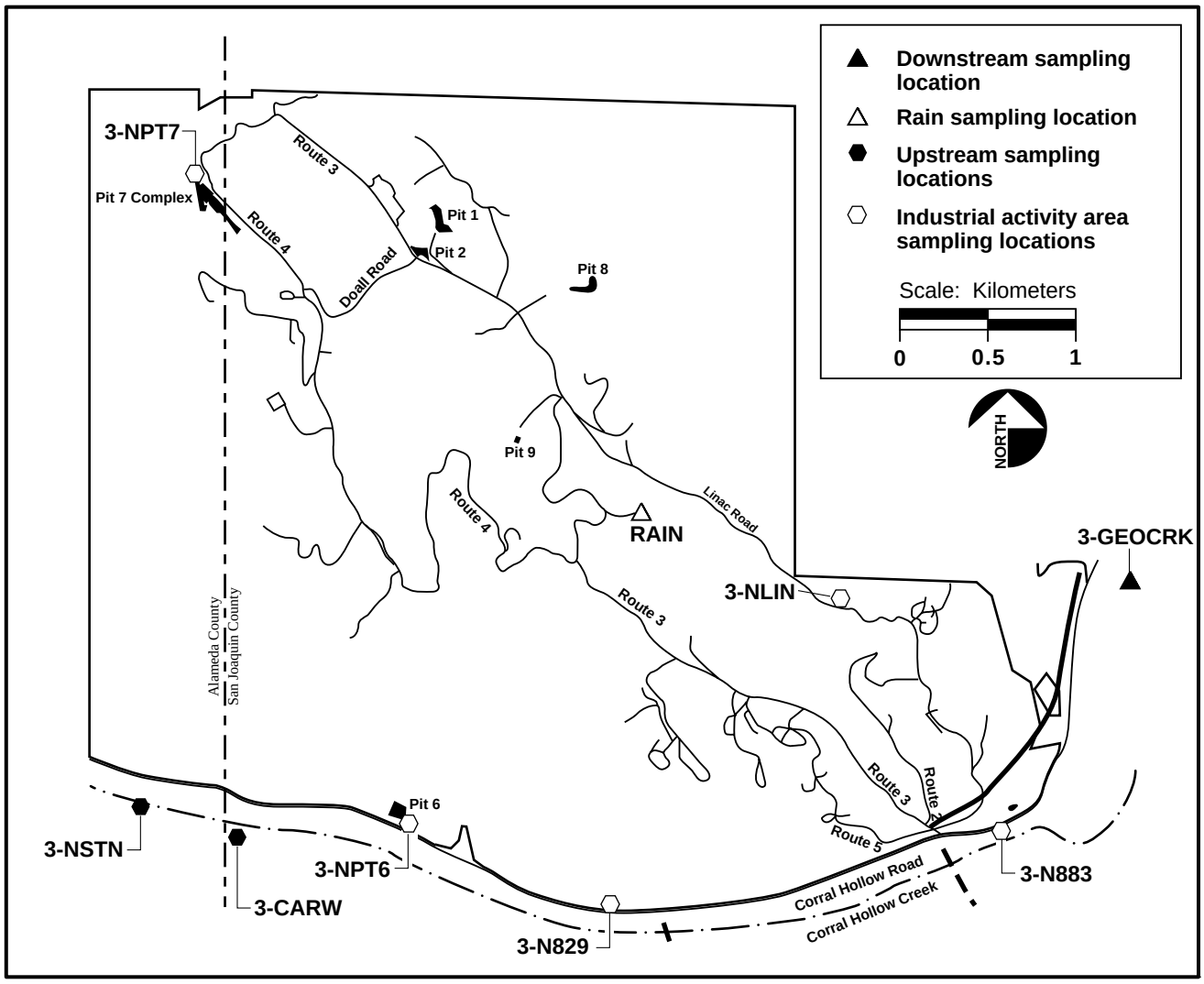

Figure 7-8. Rain and storm water runoff sampling locations, Site 300 and vicinity, 1996.

Two measurements of pH (6.12 and 6.4) were below the MCL minimum (6.5) at location N883, and one measurement (8.66) at location NPT7 was above the MCL maximum (8.5). Background specific conductance was above the California MCL (900 µmho/cm) at location NSTN (1400 µmho/cm). It was also above the MCL at the downgradient location (GEOCRK) in the same creek, but, at 1300 µmho/cm, was slightly lower than at the upgradient location. Total suspended solids were above the EPA benchmark (100 mg/L) three times at background locations NSTN and CARW, twice at on-site location NSTN, and once at downgradient location GEOCRK. High values occurred at on-site location NPT6 (1900 mg/L) and background location CARW (1200 mg/L). Historically, background total suspended solids have been as high as 20,000 mg/L, indicating that these values are due to erosion typical of the region.

Table 7-5. Radioactivity in storm water runoff at Site 300 (in Bq/L), 1996.

Location	Date	Tritium	Gross alpha	Gross beta	234U $\times 10^{-2}$	235U $\times 10^{-3}$	238U $\times 10^{-2}$
CARW	Jan 31	2.36 ± 2.20	0.814 ± 0.407	1.21 ± 0.31	4 ± 1	2.6 ± 2	2.92 ± 0.8
	Mar 13	—[a]	0.111 ± 0.074	0.222 ± 0.15	—[a]	—[a]	—[a]
GEOCRK	Jan 31	2.15 ± 2.15	0.925 ± 0.444	1.51 ± 0.33	8.66 ± 1.4	2.1 ± 2	6.88 ± 1.3
	Mar 13	—[a]	0.148 ± 0.074	0.148 ± 0.148	—[a]	—[a]	—[a]
	May 15	1.78 ± 1.78	0.329 ± 0.144	0.562 ± 0.18	4.7 ± 1.1	1.5 ± 3	4.29 ± 1
NLIN	Jan 31	2.17 ± 2.17	0.629 ± 0.407	1.35 ± 0.32	3.48 ± 1	7.4 ± 5	4 ± 1.1
N883	Jan 16	2.15 ± 2.15	0.047 ± 0.031	0.118 ± 0.052	01 ± 0.4	2.5 ± 2	0.35 ± 0.3
	Jan 31	2.09 ± 2.09	0.013 ± 0.027	0.163 ± 0.052	0.85 ± 0.5	1.8 ± 2	0.59 ± 0.4
	Oct 29	2.43 ± 2.43	0.0123 ± 0.033	0.0181 ± 0.13	–0.2 ± 0.4	–1.5 ± 2	–0.2 ± 0.3
NPT6	Jan 16	2.18 ± 2.18	4.255 ± 1.739	7.55 ± 1.33	6.77 ± 1.3	15.5 ± 6	5.99 ± 1.2
NPT7	Jan 16	2.12 ± 2.11	0.0326 ± 0.032	0.167 ± 0.056	1.55 ± 0.6	1.5 ± 2	0.7 ± 0.4
	Jan 31	2.08 ± 2.08	0.0333 ± 0.063	0.215 ± 0.059	2.89 ± 0.8	0 ± 1	2.29 ± 0.7
	Oct 29	2.47 ± 2.47	0.0256 ± 0.037	0.154 ± 0.12	0.61 ± 0.4	–1 ± 3	0.24 ± 0.2
NSTN	Jan 31	2.11 ± 2.11	0.925 ± 0.407	1.39 ± 0.26	3.66 ± 1.1	9.6 ± 6	3.85 ± 1.1
	May 15	1.78 ± 1.78	0.141 ± 0.104	0.294 ± 0.23	6.92 ± 1.2	6.3 ± 4	4.66 ± 1
STN	Mar 13	—[a]	0.185 ± 0.074	0.185 ± 0.15	—[a]	—[a]	—[a]

[a] Not sampled on March 13 on because sampling was an effort to resample only gross alpha and beta.

Rainfall

Livermore Site

Rainfall is sampled for tritium according to written procedures in Appendix A of the *Environmental Monitoring Plan* (Tate et al. 1995). Historically, the tritium activity measured in rainfall in the Livermore Valley has resulted primarily from atmospheric emissions of tritiated water vapor (HTO) from stacks at LLNL's Tritium Facility (Building 331), and Sandia National Laboratories / California's former Tritium Research Laboratory. The B343 rain sampling location is near the Tritium Facility (Building 331), where LLNL personnel have reduced operations in recent years and performed significant inventory reduction and cleanup activities. The total measured atmospheric emission of HTO from LLNL facilities in 1996 was 7.0 TBq, equal to 190 curies (Ci).

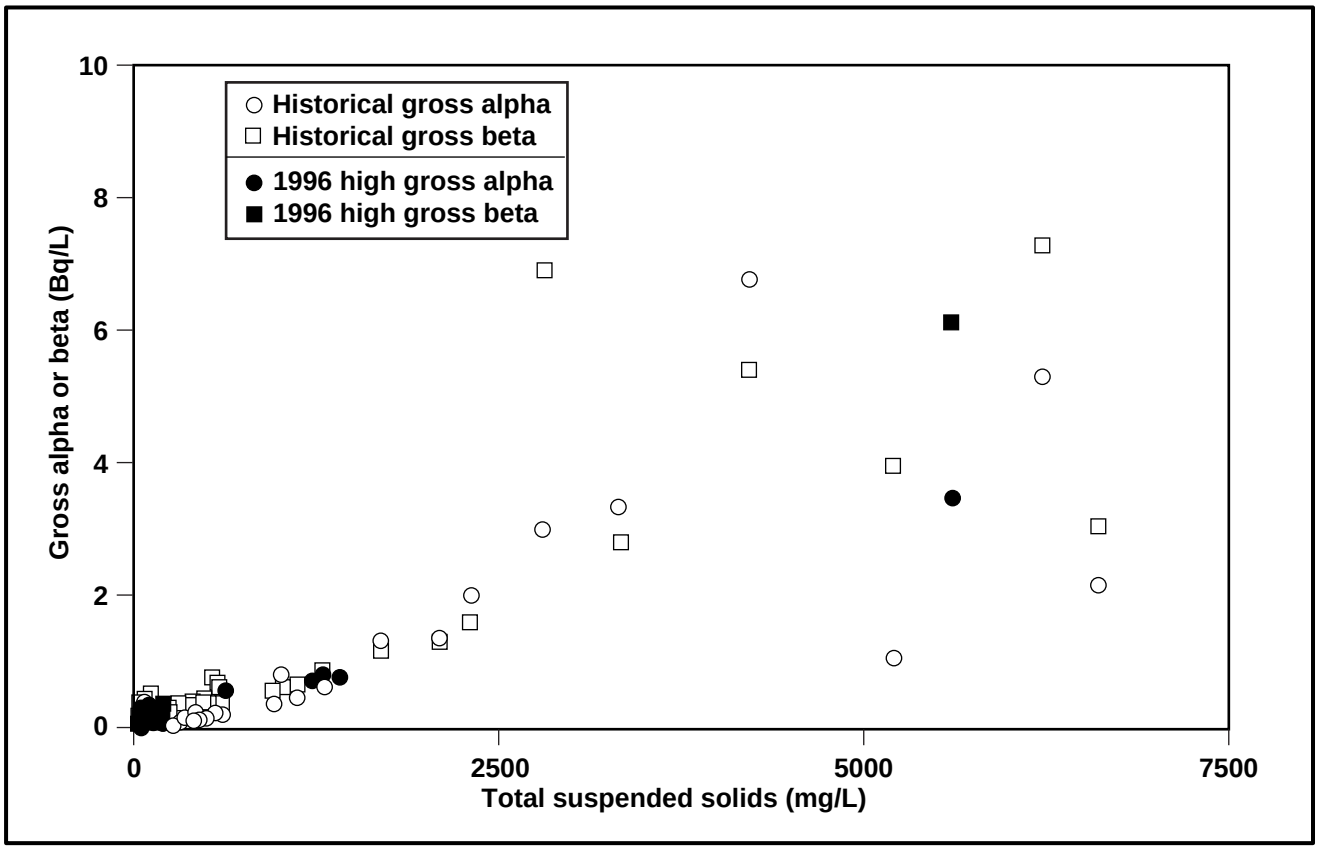

Figure 7-9. Relationship of storm water gross alpha and gross beta to total suspended solids.

The rain sampling station locations are shown on **Figure 7-10.** The fixed stations are positioned to record a wide spectrum of tritium activities in rainfall, from the maximum expected down to background levels.

Tritium activities measured in rainfall at the LLNL site and vicinity are summarized in **Table 7-6**. Complete data are shown in Volume 2, Table 7-4. The Livermore site rainfall has exhibited elevated tritium activities in the past (Gallegos et al. 1994). During 1996, however, measurements of tritium activity in rainfall were all far below the 740 Bq/L (20,000 pCi/L) MCL established by the EPA for drinking water. Rainfall samples were collected on January 17, April 1, April 18, May 16, and October 29, 1996. The highest overall activity was 170 Bq/L (4590 pCi/L) measured on October 29 near Building 343, just to the north of the on-site Tritium Facility. This value is approximately 23% of the MCL for tritium. The highest off-site activity was 9.3 Bq/L (250 pCi/L) recorded in a sample collected from station AQUE on April 18, 1996. This station is east of the former Tritium Research Laboratory at SNL/California and southeast of LLNL's Building 331.

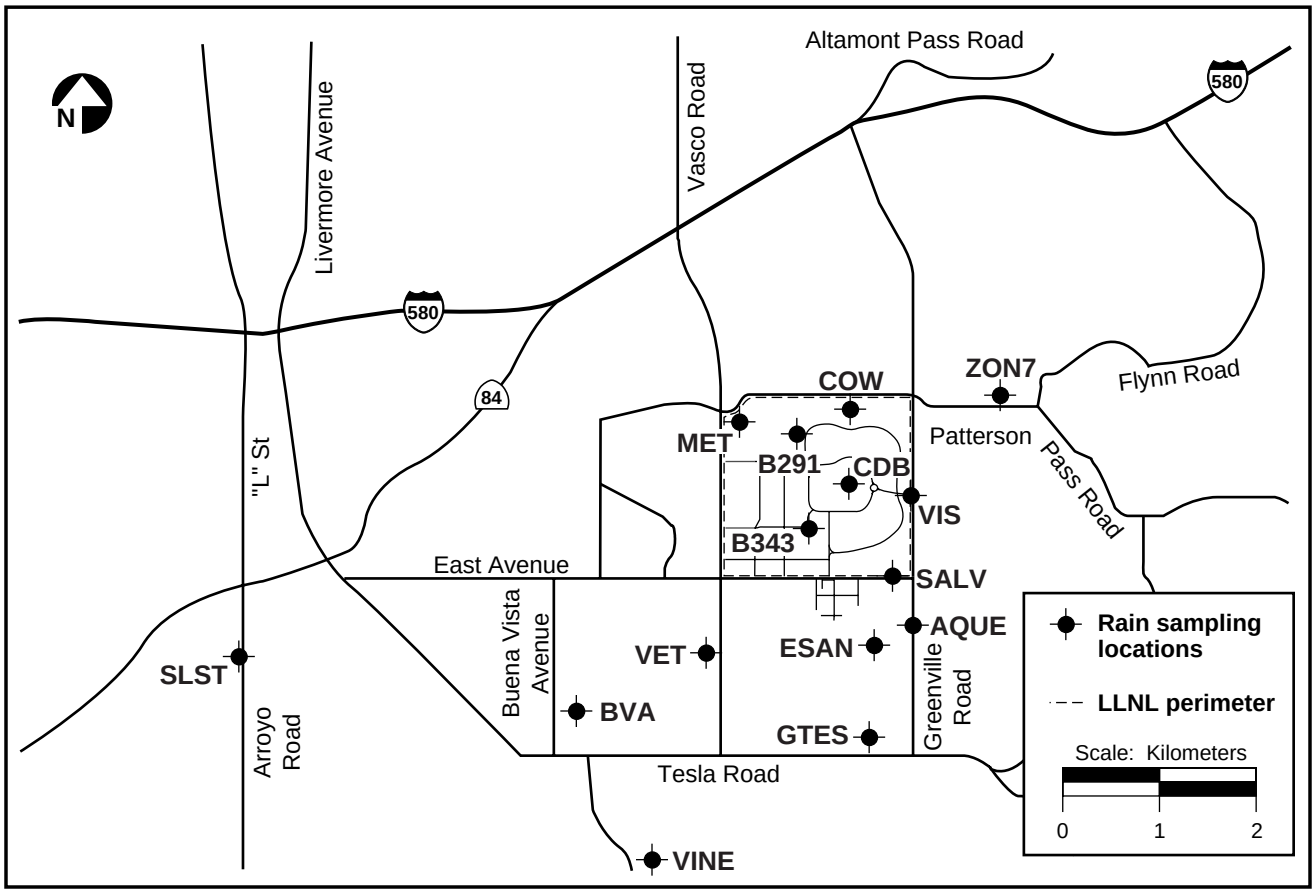

Figure 7-10. Rain sampling locations, Livermore site and Livermore Valley, 1996.

Table 7-6. Tritium activities (in Bq/L) in rainfall for the Livermore site and Livermore Valley.

	Livermore site	Livermore Valley	Overall
Median	6.0	2.0	2.2
Minimum	1.6	1.7	1.6
Maximum	170	9.3	170
Interquartile range	9.6	0.71	4.2
Number of samples	35	40	75

Tritium activity in rainfall at the Livermore site has decreased during the past 8 years. This decrease mirrors the downward trend in total HTO emissions from LLNL's Tritium Facility and SNL/California's former Tritium Research Laboratory. These trends are shown in **Figure 7-11.** Values for median tritium activity are derived from the six on-site rain sampling locations (B343, B291, CDB, SALV, VIS, and COW) that

historically have given the highest activities. A nearly five-fold decrease in total HTO emissions has occurred since 1990, down from 34.9 TBq (943 Ci) to 7.0 TBq (190 Ci). This decrease is mirrored by a more than tenfold decrease in median tritium activity measured in rainfall on site at LLNL: down from 65.9 Bq/L (1780 pCi/L) to 6.83 Bq/L, (185 pCi/L).

Site 300

One central location is used to collect rainfall for tritium activity measurements at LLNL's Experimental Test Site (Site 300) (**Figure 7-8**). Over the past 24 years, 155 measurements of rainfall samples collected at this location give a maximum tritium activity of only 9.1 Bq/L (250 pCi/L) and a median of 2.3 Bq/L (62 pCi/L), with a standard deviation of 2.1 Bq/L (57 pCi/L). The tritium activity measured in rainfall at Site 300 has been indistinguishable from atmospheric background over the past 24 years. Because of a misunderstanding by Site 300 personnel, rain samples were not collected in 1996. Sample collection resumed in 1997.

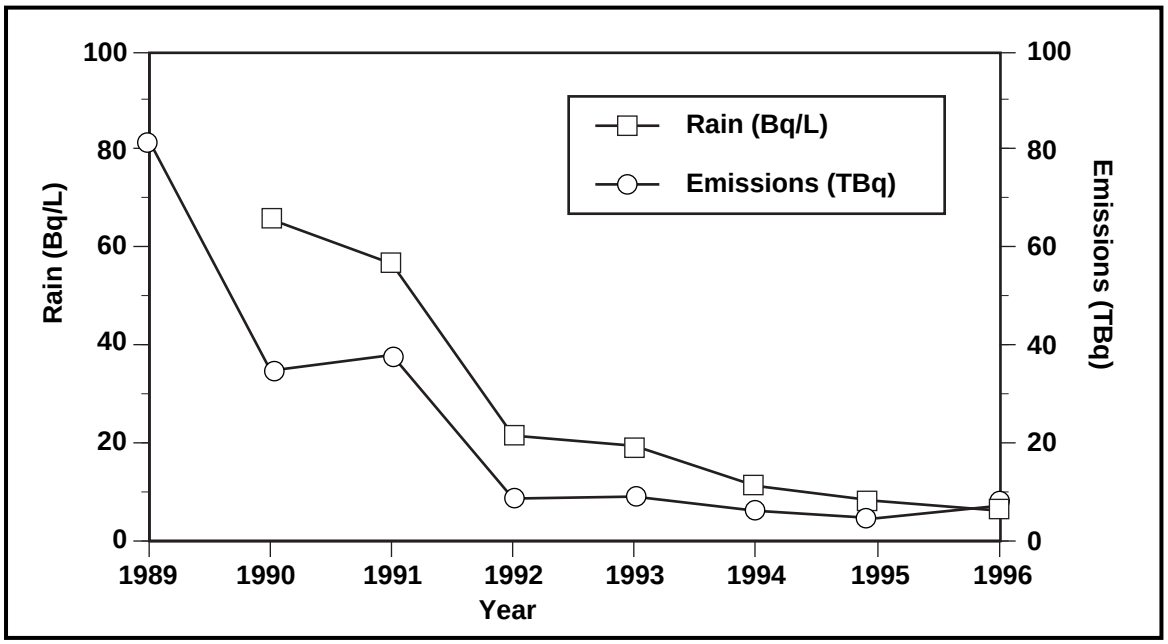

Figure 7-11. Trends of median tritium activity in rain and total stack emissions of HTO from LLNL and SNL/California, 1990 to 1996. (1996 emissions are only LLNL.)

Livermore Site Drainage Retention Basin

The Drainage Retention Basin (DRB) came into being in 1992 when remedial action studies indicated that infiltration of storm water from the existing basin caused increased dispersal of ground water contaminants. Located in the center of the Livermore site, the DRB can hold approximately 53 ML (43 acre-feet) of water.

After the basin was lined in 1992, LLNL adopted the *Drainage Retention Basin Management Plan* (The Limnion Corporation 1991). The focus of the management plan was to implement a long-term biological monitoring and maintenance program and to address water quality problems by bioremediation and reducing the nutrient load. The management plan identified two water sources to fill and maintain the level of the DRB. The primary water source was intended to be water reclaimed from ground water treatment units and discharged to the basin through the existing storm water collection system or piped directly to the DRB. The secondary water source was intended to be storm water runoff. However, since the start of operation in 1992, storm water runoff has been the primary source of water entering the DRB, with only small amounts of treated ground water being discharged to the DRB. In November 1996, Treatment Facility E began operation and became the first steady source of treated ground water entering the DRB.

The San Francisco Bay RWQCB regulates discharges from the DRB according to the Livermore site CERCLA Record of Decision (ROD) as modified by the letter from the RWQCB to DOE on August 15, 1996. The CERCLA ROD establishes discharge limits for all remedial activities at the Livermore site. In 1992, LLNL developed a sampling program for the DRB, which was approved by the San Francisco Bay RWQCB. The sampling program consists of sampling discharges from the DRB (location CDBX) and the site storm water outfall (location WPDC) during the first release from the DRB and a minimum of one additional storm (chosen in conjunction with storm water runoff monitoring). Sampling locations are shown in **Figure 7-1**. Samples are taken at CDBX to determine compliance with discharge limits. Sampling at WPDC is done at the direction of the RWQCB to identify any change in water quality as DRB discharges travel through the LLNL storm water drainage system and leave the site. Effluent limits established in the CERCLA ROD and the limits effective August 15, 1996, for discharges from the DRB, applied at CDBX, are found in **Table 7-7**.

Table 7-7. Treated ground water and Drainage Retention Basin discharge limits identified in CERCLA ROD as amended for outfalls CDBX, TFB, TFC, TFD, TFE, TFF, TFG, TF406, and TF518.

Constituents	Discharge limit Jan–Aug 1996	New discharge limits effective Aug 15, 1996	
		Dry season Apr 1–Nov 30	Wet season Dec 1–Mar 31
Metals (μg/L)			
Antimony	1460	6	not applicable
Arsenic	20	50	10
Beryllium	0.7	4	not applicable
Boron	7000	no change	no change
Cadmium	5	5	2.2
Chromium (total)	50	50	not applicable
Chromium(VI)	11	not applicable	22
Copper	20	1300	23.6
Iron	3000	no change	no change
Lead	5.6	15	6.4
Manganese	500	no change	no change
Mercury	1	2	<1g/day
Nickel	7.1	320	100
Selenium	100	50	10
Silver	2.3	100	8.2
Thallium	130	2	not applicable
Zinc	58	not applicable	220
Organics (μg/L)			
Volatile organic compounds (total)	5	no change	no change
Benzene	0.7	no change	no change
Tetrachloroethene	4	no change	no change
Vinyl chloride	2	no change	no change
1,2-Dibromoethane	0.02	no change	no change
Total petroleum hydrocarbons	50	no change	no change
Polynuclear aromatic hydrocarbons	15	no change	no change
Base/neutral and acid extractable compounds and pesticides	5	no change	no change
Physical			
pH	6.5–8.5	no change	no change
Toxicity			
Aquatic survival bioassay (96 hours)	90% survival median, 90 percentile value of not less than 70% survival	no change	no change

By agreement with the San Francisco Bay RWQCB, every quarter LLNL summarizes weekly, monthly, quarterly, semiannual, and annual monitoring of the basin as specified in the *Drainage Retention Basin Management Plan* (The Limnion Corporation 1991). Sampling to determine whether water quality management objectives are met is conducted at several points within the DRB. Water at eight locations (**Figure 7-12**) is sampled for dissolved oxygen and the temperature measured. Because of limited variability among sampling locations, all samples, other than dissolved oxygen and temperature, are routinely collected from CDBE, located at the middle depth of the DRB. The routine management constituents are identified in **Table 7-8**. This year, LLNL added additional management constituents and increased monitoring frequencies for other constituents to better understand the dynamics within the DRB. Those constituents added or frequencies changed are highlighted in bold text within **Table 7-8**.

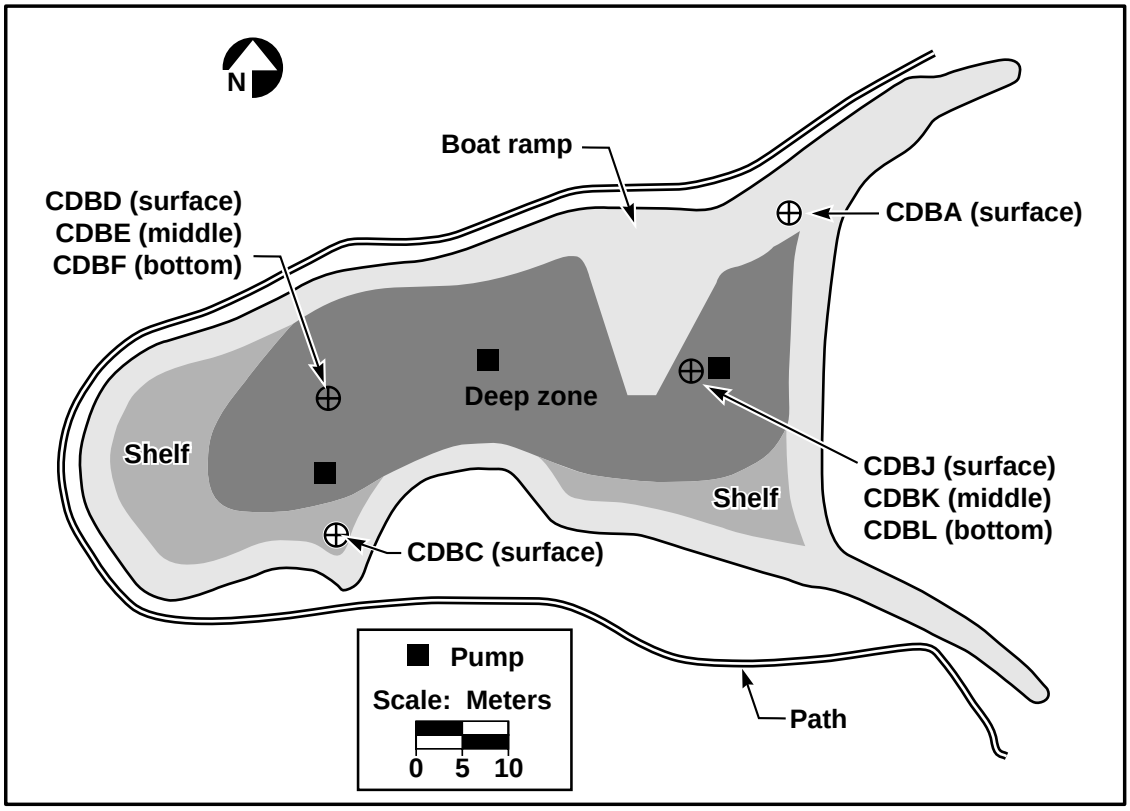

Figure 7-12. Sampling locations within the Drainage Retention Basin, 1996.

Table 7-8. Routine water quality management levels for the Drainage Retention Basin. Constituents added or frequencies changed are displayed in bold-face type.

Constituents	Location	Frequency	Management action levels	New discharge limits effective Aug 15, 1996	
			Jan–Aug 1996	Dry season Apr 1–Nov 30	Wet season Dec 1–Mar 31
Physical					
Dissolved oxygen (mg/L)	CDBA, CDBC, CDBD, CDBE, CDBF, CDFJ, CDBK, CDBL	Weekly	<80% saturation	no change	no change
Temperature (°C)	CDBA, CDBC, CDBD, CDBE, CDBF, CDFJ, CDBK, CDBL	Weekly	<15 and >26	no change	no change
Total alkalinity (as $CaCO_3$) (mg/L)	CDBE	Monthly	<50	no change	no change
Chlorophyll-a (mg/L)	CDBE	Monthly	>10	no change	no change
pH	CDBA, CDBC, CDBD, CDBE, CDBF, CDFJ, CDBK, CDBL	Weekly	<6.0 and >9.0	no change	no change
Total suspended solids (mg/L)	CDBE	Monthly	none	no change	no change
Total dissolved solids (mg/L)	CDBE	Monthly	>350	no change	no change
Turbidity (m)	CDBE	Monthly	<0.914	no change	no change
Chemical oxygen demand (mg/L)	CDBE	Quarterly	>20	no change	no change
Oil and grease (mg/L)	CDBE	Quarterly	>15	no change	no change
Conductivity (μmho/cm)	CDBE	Monthly	>900	no change	no change
Nutrients (mg/L)					
Nitrate	CDBE	Monthly	>0.2	no change	no change
Nitrite	CDBE	Monthly	>0.2	no change	no change
Ammonia nitrogen	CDBE	Monthly	>0.1	no change	no change
Phosphate (as phosphorous)	CDBE	Monthly	>0.02	no change	no change
Microbiological (MPN[(a)]/0.1L)					
Total coliform	CDBE	Quarterly	>5000	no change	no change
Fecal coliform	CDBE	Quarterly	>400	no change	no change

Table 7-8. Routine water quality management levels for the Drainage Retention Basin Constituents added or frequencies changed are displayed in bold-face type (continued).

Constituents	Location	Frequency	Management action levels	New discharge limits effective Aug 15, 1996	
			Jan–Aug 1996	Dry season Apr 1–Nov 30	Wet season Dec 1–Mar 31
Metals (μg/L)					
Antimony	CDBE	**Monthly**	>1460	6	not applicable
Arsenic	CDBE	**Monthly**	>20	50	10
Beryllium	CDBE	**Monthly**	>0.7	4	not applicable
Boron	CDBE	**Monthly**	>7000	no change	no change
Cadmium	CDBE	**Monthly**	>5	5	2.2
Chromium, total	CDBE	**Monthly**	>50	50	not applicable
Chromium(VI)	CDBE	**Monthly**	>11	not applicable	22
Copper	CDBE	**Monthly**	>20	1300	23.6
Iron	CDBE	**Monthly**	>3000	no change	no change
Lead	CDBE	**Monthly**	>2	15	6.4
Manganese	CDBE	**Monthly**	>500	no change	no change
Mercury	CDBE	**Monthly**	>1	2	<1g/day
Nickel	CDBE	**Monthly**	>7.1	320	100
Selenium	CDBE	**Monthly**	>100	50	10
Silver	CDBE	**Monthly**	>2.3	100	8.2
Thallium	CDBE	**Monthly**	>130	2	not applicable
Zinc	CDBE	**Monthly**	>58	not applicable	220
Organics (μg/L)					
Total volatile organic compounds	CDBE	Semiannually	>5	no change	no change
Benzene	CDBE	Semiannually	>0.7	no change	no change
Tetrachloroethene	CDBE	Semiannually	>4	no change	no change
Vinyl chloride	CDBE	Semiannually	>2	no change	no change
Ethylene dibromide	CDBE	Semiannually	>0.02	no change	no change
Total petroleum hydrocarbons	CDBE	Semiannually	>50	no change	no change
Polynuclear aromatic hydrocarbons	CDBE	Semiannually	>15	no change	no change
Base/neutral acid extractable compounds	CDBE	Semiannually	>5	no change	no change
Pesticides and **herbicides**	**CDBE**	**Quarterly**	**not applicable**	**not applicable**	**not applicable**

Table 7-8. Routine water quality management levels for the Drainage Retention Basin Constituents added or frequencies changed are displayed in bold-face type (concluded).

Constituents	Location	Frequency	Management action levels	New discharge limits effective Aug 15, 1996	
			Jan–Aug 1996	Dry season Apr 1–Nov 30	Wet season Dec 1–Mar 31
Radiological (pCi/L)					
Gross alpha	CDBE	Semiannually	>15	no change	no change
Gross beta	CDBE	Semiannually	>50	no change	no change
Tritium	CDBE	Semiannually	>20,000	no change	no change
Toxicity (% survival/96-hour)					
Aquatic bioassay fathead minnow	CDBE	Annually	90% survival median, 90 percentile value of not less than 70% survival	no change	no change
Chronic bioassay fathead minnow	**CDBE**	**Annually**	**not applicable**	**not applicable**	**not applicable**
Chronic bioassay selanastrum	**CDBE**	**Annually**	**not applicable**	**not applicable**	**not applicable**

[a] Most probable number.

During 1996, two of the thirteen discharges from the DRB were sampled at CDBX. Both samples exceed the amended discharge limits for iron (**Table 7-9**). Iron concentrations were also above the DRB discharge limit in samples collected at WPDC, the storm water outflow monitoring location at Arroyo Las Positas. Iron above discharge limits first

Table 7-9. Drainage Retention Basin monitoring event in which the concentration of metals exceeded discharge limits at CDBX shown with associated metal concentration at WPDC. Bold print denotes samples exceeding discharge limits in effect at the time the sample was collected.

Constituents (μg/L)	Location, result (μg/L)				Discharge limit	New discharge limits effective August 15, 1996 (μg/L)	
	January 16, 1996		November 19, 1996		Jan–Aug 1996	Dry season	Wet season
	CDBX	WPDC	CDBX	WPDC	(μg/L)	Apr 1–Nov 30	Dec 1–Mar 31
Iron	**3200**	**9700**	**3900**	2900	3000	no change	no change
Lead	4.1	**7.7**	<5	<5	5.6	15	6.4
Nickel	**9.7**	**21**	13	<2	7.1	320	100
Zinc	51	**130**	110	96	58	not applicable	220

appeared in DRB releases in the December 1995 sample. Previously, in samples of discharges from the DRB collected at CDBX from 1992 through 1994, iron was not present above discharge limits. However, because WPDC storm water includes flow from off site, other on-site locations, and from treatment facilities, data collected at this sampling location are not used to determine compliance with the discharge limits applied to the DRB releases. As stated earlier, WPDC sample are used to determine how the water quality changes as discharges flow through LLNL's storm drainage system before they eventually exit the Livermore site at WPDC.

January discharges from the DRB, which occurred before the implementation of the amended discharge limits, exceeded the discharge limit in effect at that time for nickel. Concurrent samples collected at WPDC exceeded the discharge limits in effect for zinc, lead, and nickel. Samples collected at the WPDC represent a combination of storm water running onto the Livermore site, storm water running off the site, NPDES-permitted treated ground water and process discharges, and the DRB release. Metals concentrations in the sample collected at location WPDC were generally higher than samples collected from the DRB discharge, showing that the presence of these metals at CDBX is consistent with typical storm water runoff from the site.

Samples collected during 1996 within the DRB at sample location CDBE did not meet the management action levels (MALs) as amended by the August 15, 1996, letter for alkalinity, nitrate, nitrite, ammonia, phosphorus, turbidity, temperature, alkalinity, and iron (**Table 7-10**). Prior to August 15, 1996, samples collected within the DRB at sample location CDBE also exceeded the MALs for arsenic, chromium(VI), lead, nickel, and zinc. No action was taken to adjust nutrient and metals levels. Monitoring frequencies for metals were increased from the required semiannual monitoring to monthly to more closely track concentration changes. Alkalinity monitoring was increased to weekly field measurements to more closely track water quality.

Dissolved oxygen concentrations varied around the MAL of at least 80% saturation of oxygen in the water. The concentration of dissolved oxygen in the DRB only occasionally dropped below the critical management action level of 5 mg/L, and this was at location CDBL, which is located near the bottom of the DRB. Monthly average dissolved oxygen concentrations (**Figure 7-13**), however, were all well above 5 mg/L. Dissolved oxygen levels were controlled manually with aeration pumps, which are started whenever oxygen levels at any level of the DRB drop close to or below the critical MAL of 5 mg/L. Typically, these pumps are used continuously through the spring, summer, and fall months. During the winter, the pumps are started as needed.

Table 7-10. Results of Drainage Retention Basin monitoring at sampling location CDBE. Events exceeding management action levels are in bold-face type. Discharge limits for some constituents were amended on August 15, 1996.

Constituents	Management action level	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperature (°C)	<15.6 >26.7	**11.7**	16.6	**13.1**	16.4	19.1	22	23.7	23.4	20.7	18.8	**11.2**	**11.5**
Turbidity (secchi disk) (m)	<0.914	0.401	0.178	0.146	0.184	0.275	0.411	0.36	0.347	0.389	0.406	0.347	0.474
Alkalinity (as $CaCo_3$) (mg/L)	<50	44	40	29	24	29	38	39.2	41.3	100	47.8	46.3	41.3
Nitrate (as N) (mg/L)	≥0.2	—[a]	—[a]	—[a]	**0.41**	**<0.5**	**<0.5**	**0.4**	**0.4**	**<0.5**	**0.2**	**0.4**	**0.6**
Nitrite (as N) (mg/L)	≥0.2	**<0.5**	**<0.5**	<0.05	<0.05	**<0.5**	**<0.5**	<0.1	<0.1	**<0.5**	<0.1	<0.1	<0.1
Ammonia nitrogen (mg/L)	>0.1	**0.18**	**3.9**	<0.05	<0.05	**0.3**	0.1	**<0.5**	<0.02	**0.2**	<0.02	0.06	0.02
Phosphate (as P) (mg/L)	≥0.02	**0.076**	**0.092**	**0.15**	**0.19**	**0.21**	**0.2**	**0.24**	**0.24**	**0.22**	**0.24**	**0.22**	**0.19**
Arsenic (µg/L)[a]	20	3.9	**21**	<2	<2	2.7	2.1	3	<2	<2	3.3	3.5	2.2
Chromium(VI) (µg/L)[b]	11	—[c]	—[c]	<2	<2	2	**12**	<2	<2	2	2	>2	<2
Iron (µg/L)	>3000	2100	**6000**	**10000**	**5100**	**4400**	**4500**	**4080**	**3460**	**3900**	**3200**	2390	2300
Lead (µg/L)[d]	>2	**2.6**	**3.4**	**3**	<2	**2.8**	**2.7**	**<5**	**<5**	**4.2**	**<5**	**<5**	**<5**
Nickel (µg/L)[e]	>7.1	**7.7**	**16**	**18**	**13**	**8.7**	**12**	**10**	**12**	**10**	**22**	**8**	7
Zinc (µg/L)[f]	>58	47	58	**70**	50	54	49	**66**	**62**	<20	41	**63**	47

a Discharge limit amended to 50 µg/L for wet season and 10 µg/L for dry season.

b Discharge limit amended to 22 µg/L for dry season.

c Not measured.

d Discharge limit amended to 15 µg/L for wet season and 16.4 µg/L for dry season.

e Discharge limit amended to 100 µg/L for wet season and 320 µg/L for dry season.

f Discharge limit amended to 220 µg/L for dry season.

Pump operation is probably responsible for the relatively uniform distribution of dissolved oxygen at the surface, middle, and bottom elevations seen throughout the 3 years of DRB operation. Adequate dissolved-oxygen levels prevent nutrient release back into the DRB water column by decaying organic matter in the bottom sediments. Temperature, the other important parameter in determining how much oxygen is dissolved in water, showed characteristic seasonal trends. The uniform distribution of temperature in the top, middle, and bottom elevations also reflects the uniform mixing achieved by the operation of the pumps. Without mixing, the water temperature would be expected to show seasonal stratification in addition to the changes in temperature with depth.

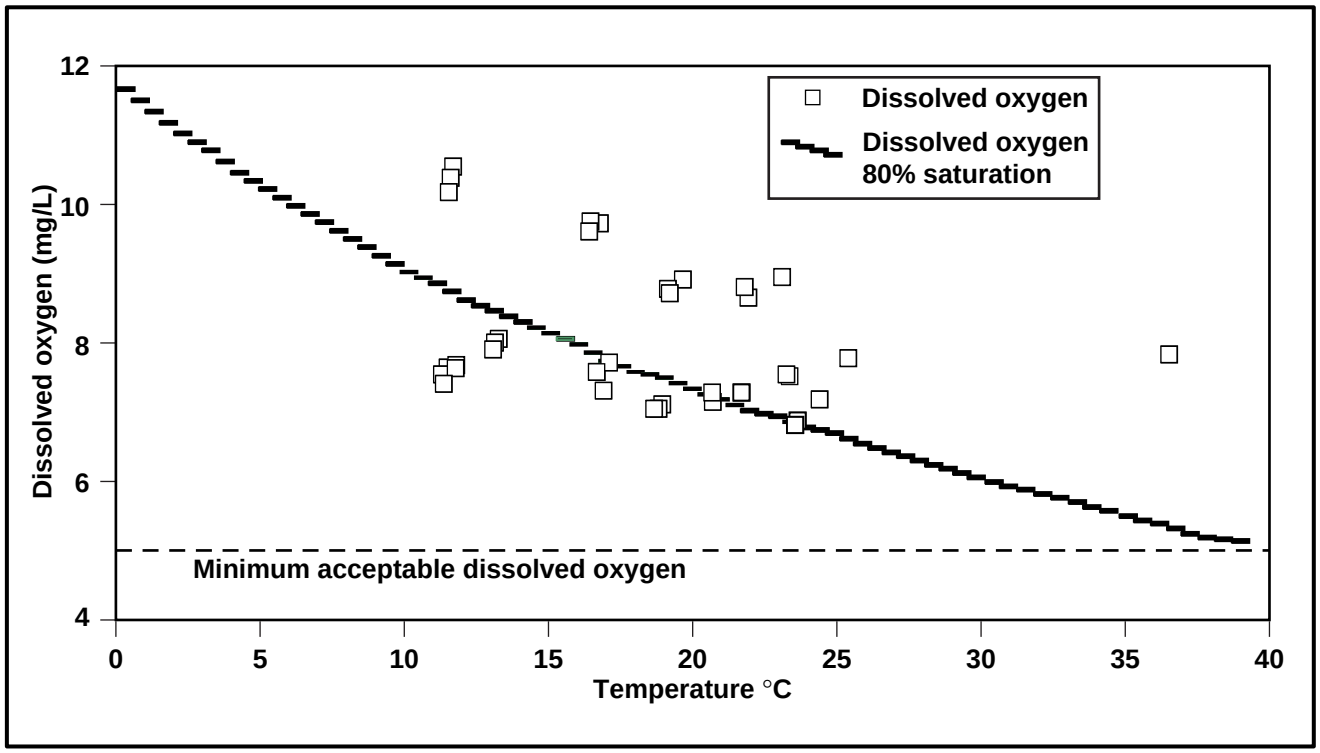

Figure 7-13. Monthly average dissolved oxygen vs temperature at each depth location in the Drainage Retention Basin from January through December 1996.

Turbidity rose above acceptable management levels during the 1993–1994 wet season, and throughout 1994 and 1995. Wet season turbidity probably results from sediments that pass through the sediment traps discharging into the DRB. Turbidity seen during the warmer summer months of 1994 was most likely the result of algae growth (Harrach et al. 1996). This was confirmed by high chlorophyll-a values and visual observations during the 1994 summer months. However, during 1995, though turbidity continued to be high, chlorophyll-a values were just above detection, indicating very little algae growth. This relationship continued through 1996 with visual observations made during sampling events, confirming that there was little or no algae growth. In January 1995, total alkalinity dropped below the MAL for the first time since June 1993 and continued mostly below the MAL throughout 1995 and 1996. Turbidity, alkalinity, and chlorophyll-a collected at sample location CDBE vary together, indicating that the chlorophyll-a varies with these two parameters (**Figure 7-14**).

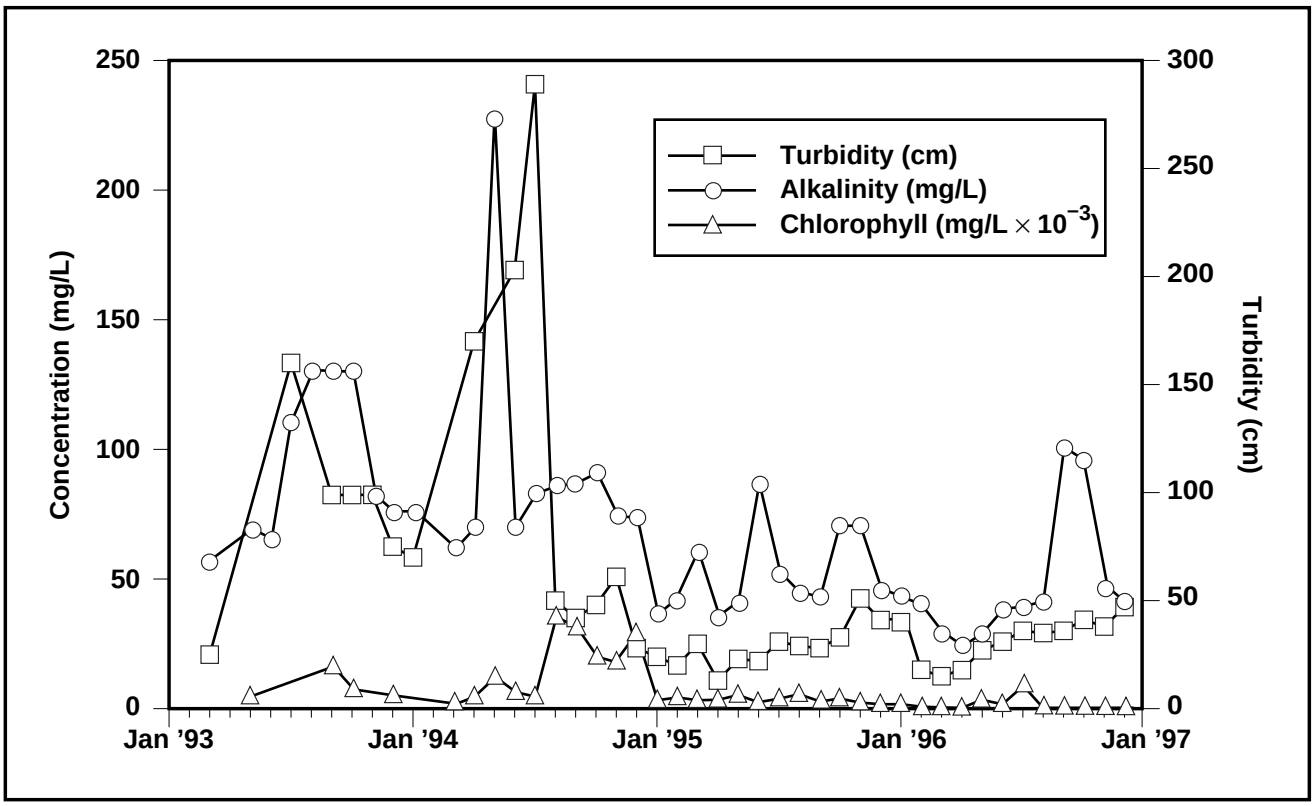

Figure 7-14. Correlation between concentration of chlorophyll-a and turbidity and alkalinity at monitoring point CDBE.

During September 1996, LLNL again conducted chronic toxicity tests on algae and fish to determine if the lack of algae growth was due to something other than the high turbidity, which would reduce light penetration in the water and limit the size of the photic zone where plant growth could occur. The results of the test using algae, *Selanastrum capricornutum*, indicated that algae growth in DRB water was actually enhanced above the control sample, a result that was different from the 1995 tests showing algae growth inhibition in the DRB sample. This test also was inconsistent with the chlorophyll-a results and visual observations, which indicated that the DRB water did not have a growth-enhancing affect on the algae. It is possible that the main cause of the reduced algae in the DRB in the fall of 1996 was the turbidity. The test using fathead minnow, *Pimephales promelas,* showed no chronic toxicity in 100% DRB water.

LLNL is continuing to study the cause of the low algae growth within the DRB as well as investigating a means to remove the turbidity, increase the alkalinity of the DRB water, and establish a viable plant community within the DRB.

LLNL began monitoring the flow discharging from the DRB in 1996 (see **Figure 7-15**). Discharges from the DRB occur during storm events and trail off as runoff enters and exits the DRB. Because storm water runoff accounts for the majority of the water entering the DRB, discharges occur only in the wet season, and all discharged water is associated with storm events. The volume of flow into the DRB from the only other contributing source, Treatment Facility E discharges, though continuous through the year is not enough to result in dry season discharges. A total of 105.8 ML (28 million gal) of water was discharged from the DRB in the months of January, February, March, May, November, and December. The largest single discharge occurred on December 21, 1996, when 13.6 ML (3.6 million gal) was released. Mass loadings can be determined for discharges from the DRB now that flow data is available. The data show that the total mass of metals and organics released from the DRB is small.

Data for maintenance monitoring at sampling locations CDBE , CDBX, and CDBA through L and for WPDC samples collected concurrent with DRB releases are presented in Tables 7-3, 7-4, and 7-5 in Volume 2.

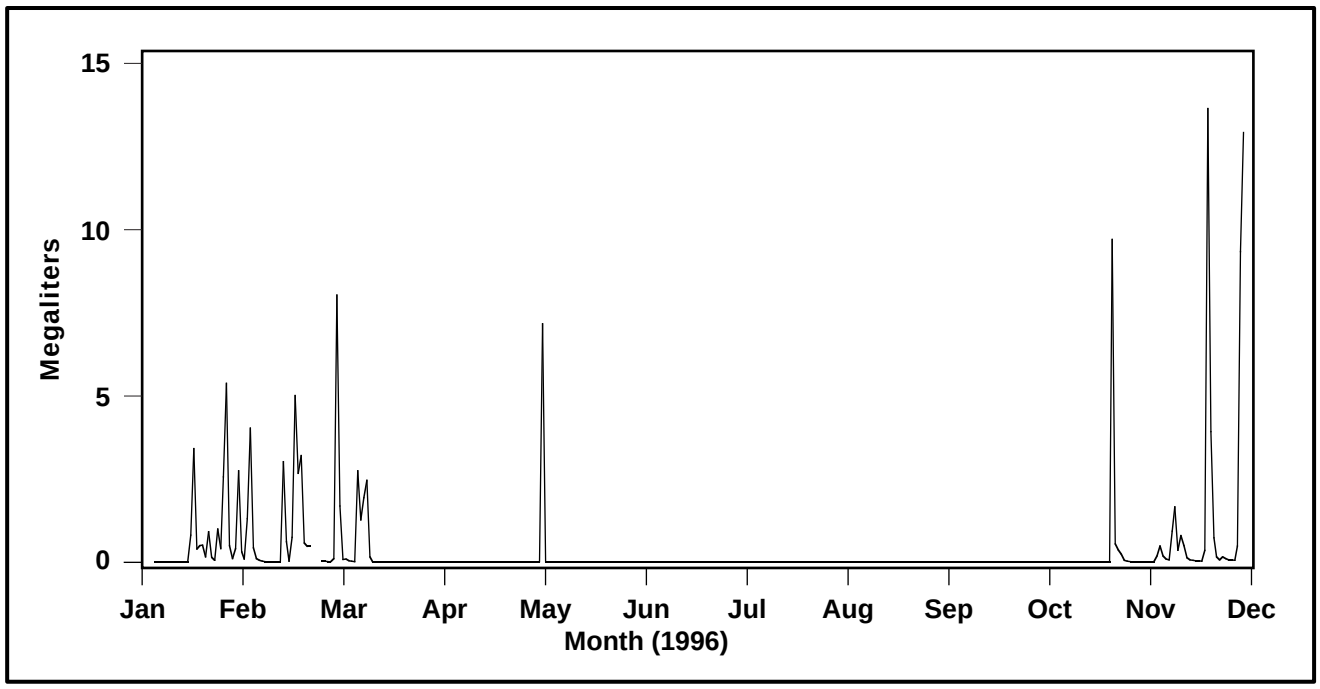

Figure 7-15. Water discharged from the Drainage Retention Basin in 1996.

Treatment Facilities

The Livermore Site Ground Water Project (GWP) complies with provisions specified in a federal facility agreement (FFA) and in the CERCLA ROD entered into by the Environmental Protection Agency (EPA), DOE, the California EPA's Department of Toxic Substances Control (DTSC), and the San Francisco Bay Regional Water Quality Control Board (RWQCB). As required by the agreement, the project addresses compliance issues through investigations of potential contamination source areas (such as suspected old release sites, solvent handling areas, and leaking underground tank systems), continued monitoring of ground water, and remediation. The ground water constituents of concern are volatile organic compounds (VOCs), primarily trichloroethylene (TCE) and tetrachloroethylene (PCE). The primary treatment technology employed at the Livermore site to remediate contaminated ground water is ground water pump-and-treat. This technology employs a dense network of ground water extraction wells, monitoring wells, pipelines, and surface treatment facilities. At Site 300, ongoing remedial investigations, feasibility studies, engineering evaluation and cost analyses, and remedial actions are being performed by the Environmental Restoration Program and Division. Site 300 investigations and remedial actions are conducted under the joint oversight of the EPA, Central Valley RWQCB, and DTSC and the authority of an FFA for the site. (There are separate agreements for Site 300 and the Livermore site.) Similar pump-and-treat technology is utilized in the General Services Area of Site 300. Treatment facility operations and ground water extraction and cleanup activities that involve discharges to the surface are discussed in this section.

Livermore Site

Treatment Facility B (TFB). Treatment Facility B (TFB) is located along Vasco Road just north of Mesquite Way (**Figure 7-16**). TFB processes ground water contaminated with chromium and VOCs using a combination of UV / H_2O_2 treatment and air-stripping technologies. TFB's treated waters are discharged into a drainage ditch at the west perimeter of the site that feeds into Arroyo Las Positas. TFB treated about 57 ML of ground water in 1996, removing and destroying approximately 7.7 kg of VOCs. Between system startup in 1990 and 1996, TFB processed 180 ML of ground water and removed about 20.1 kg of VOCs from the subsurface.

Self-monitoring analytical results of TFB effluent samples indicate that the VOC discharge limit of 5 ppb was not exceeded. Chromium(VI) is removed by reducing it with hydrogen peroxide, under controlled pH, to chromium(III). During part of 1996, water discharged from TFB contained chromium(VI) slightly in excess of the 0.011 parts per million discharge limit. Beginning in mid-July 1996, adjustments were made to the treatment process (pH and hydrogen peroxide concentration) that reduced the chromium(VI) to less than the discharge limit. The exceedances were reported to and discussed with the regulatory agencies (USEPA, California DTSC, and California

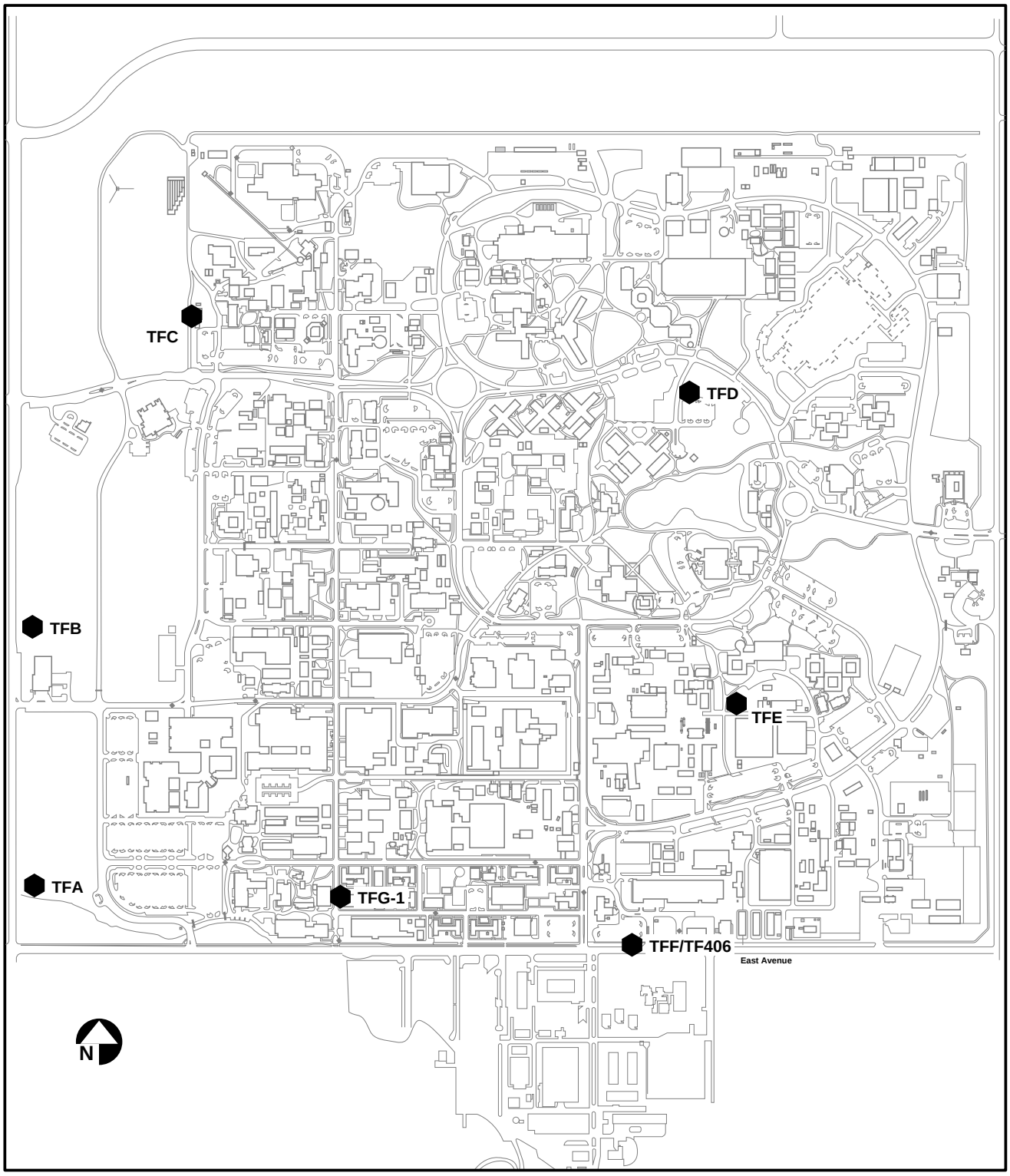

Figure 7-16. Location of water treatment facilities.

RWQCB) at regularly scheduled CERCLA monthly Remedial Project Managers' meetings and documented in the minutes of those meetings. LLNL conducted samplings at TFB in accordance with the CERCLA ROD as amended (**Table 7-7**).

Treatment Facility C. Treatment Facility C (TFC) is located in the northwest quadrant of LLNL and uses air-stripping and ion-exchange technologies to process ground water contaminated with VOCs and chromium (**Figure 7-16**). In 1996, a total of 7.7 kg of VOCs was removed from approximately 57 ML of ground water treated at TFC. Between system startup in October 1993 and 1996, TFC processed about 181.7 ML of ground water and removed about 20.1 kg of VOCs. The treated water from TFC is discharged into Arroyo Las Positas.

LLNL conducted samplings at TFC in compliance with the modified CERCLA ROD (**Table 7-7**). The self-monitoring analytical results of TFC effluent samples indicate that the VOC discharge limit of 5 ppb was not exceeded during 1996. All regulated metals parameters were below discharge limits designated in the CERCLA ROD as amended.

Treatment Facility D. Treatment Facility D (TFD) is located in the northeast quadrant of LLNL and uses air-stripping and ion-exchange technologies to process contaminated ground water (**Figure 7-16**). TFD was activated on July 14, 1994, and began operating on September 15, 1994. Since startup, TFD has processed nearly 49.2 ML of ground water and removed about 18 kg of VOC mass from the subsurface. In 1996, TFD processed about 41 ML of ground water containing about 12.1 kg of VOCs. The treated water was discharged to a storm water drainage channel discharging into Arroyo Las Positas.

LLNL conducted samplings at TFD in compliance with the modified CERCLA ROD. The self-monitoring analytical results of TFD effluent samples indicated that metals and VOCs were within compliance discharge limits during 1996.

Treatment Facility E. Treatment Facility E (TFE) is located in the southeast quadrant of the Livermore site and will consist of multiple portable treatment units (PTUs) that use air stripping to treat ground water (**Figure 7-16**). The TFE East PTU was activated on November 25, 1996. Wells W-566 and W-1109 supplied 77 L/min of ground water to the treatment facility, which operated for 6 hours each working day (Monday through Friday) during the first 2 weeks. From that point on, TFE East began operating 24 hours a day. Wells W-1109 and W-566 produce about 19 and 57 L/min ground water from hydrostratigraphic units (HSUs) 2 and 5, respectively.

TFE East PTU processed about 1.9 ML of ground water through the end of 1996, and removed an estimated 0.8 kg of VOC mass from the subsurface. Water treated at TFE East is discharged to a north-flowing drainage ditch that ultimately empties into the

Drainage Retention Basin. This requires compliance with regulatory requirements as set out in **Table 7-7**. During 1996, TFE was in compliance with the amended CERCLA ROD.

Treatment Facility F (TFF). TFF was located in the southeastern part of the Livermore site in the TF406 area (**Figure 7-16**), where hydrostratigraphic units 2, 3A, and 3B had been impacted by a fuel hydrocarbon (FHC) spill (Dresen et al. 1986). Prior to remediation, significant FHC concentrations existed in both the unsaturated and saturated zones. Currently, low concentrations of VOCs exist in the FHC ground water plume beneath the TF406 area.

During 1996, passive bioremediation was implemented in the TFF area, which resulted in the permanent discontinuation of ground water extraction and treatment for residual dissolved FHCs from HSUs 3A and 3B. Before its permanent shutdown, TFF operation was interrupted for 194 days as a result of storm damage that occurred on December 8, 1995. During June 1996, ground water was extracted and treated at TFF for a total of 6 hours to evaluate FHC concentrations in ground water extracted from HSU 3B well GEW-816. No rebound of FHC concentrations was observed in ground water from GEW-816. Following submittal of *Application for Containment Zone for the Livermore Site Hydrocarbon Impacted Zone at Treatment Facility F* (Happel et al. 1996), "No Further Action" status was granted by the regulatory agencies on October 30, 1996 (SFBRWQCB 1996). As part of the terms of this agreement, HSU 3 wells in this area will be sampled and analyzed for FHCs on a semiannual basis.

Since the facility did not discharge to the surface during the 1996 period, there were no surface water compliance issues.

Treatment Facility 406 (TF406). Located in the southeastern part of the Livermore site (**Figure 7-16**), TF406 consists of a PTU that uses air stripping to treat ground water. TF406 is designed to treat VOCs extracted from HSUs 4 and 5 beneath the former TFF area.

TF406 began operating on August 27, 1996. TF406 processes ground water extracted from Well W-1114, which is positioned to clean up and hydraulically control a TCE plume in HSU 5. In the spring of 1997, LLNL plans to start treating ground water from HSU 4 extraction Well GSW-445.

During 1996, TF406 processed about 1.5 ML of ground water from Well W-1114 at flow rates between 38 and 60 L/min. The total VOC mass removed during 1996 was about 0.2 kg. All treated ground water was discharged to a storm drain that leads to Arroyo Las Positas. There were no compliance violations associated with this discharge during 1996.

Treatment Facility G (TFG-1). Treatment Facility G-1 (TFG-1) is located about 90 m (300 ft) north of East Avenue in the south-central part of the Livermore site (**Figure 7-16**). TFG-1 consists of a PTU that utilizes air stripping and ion exchange to treat ground water from HSU 2 extraction well W-1111.

During 1996, TFG-1 processed about 3.4 ML of ground water at an average flow rate of 30 L/min. TFG-1 has removed an estimated 0.2 kg of VOCs since operation began on April 11, 1996. All treated ground water has been discharged to a storm drain located about 15 m north of TFG-1, which empties into Arroyo Seco. There were no compliance violations associated with this discharge during 1996.

Site 300

General Services Area

The central GSA ground water treatment system is operating under Substantive Requirements for wastewater discharge issued by the Central Valley RWQCB. The central GSA treatment facility discharges to bedrock in the eastern GSA canyon, where the water percolates to the surface. The eastern GSA ground water treatment system operates under NPDES permit No. CA0082651, WDR 91-052 issued by the Central Valley RWQCB for discharges into Corral Hollow Creek. Effluent limitations for the central and eastern GSA ground water treatment system are listed in **Table 7-11**. Both the central and eastern GSA treatment systems operated in compliance with regulatory requirements during 1996. The GSA operable unit is located in the southeastern corner of Site 300. Since 1982, LLNL has conducted an intensive investigation in the GSA and off-site areas to locate VOC release points and to define the vertical and horizontal distribution of VOCs, primarily TCE and PCE, in the soil, rock, and ground water. According to the *Final Site-Wide Remedial Investigation* (Webster-Scholten 1994) and *Draft Remedial Investigation* (McIlvride et al. 1990) reports, VOCs in excess of drinking water MCLs have been identified in the shallow ground water beneath the GSA in two localities. Two small VOC plumes occur in the central GSA portion of the operable unit, and one VOC plume occurs in the eastern GSA section in the gravels of Corral Hollow Creek.

An air-sparging ground water treatment unit that removes VOCs from the eastern GSA ground water began operation in June 1991 as a CERCLA Removal Action and has been operated throughout 1996. The total volume of water treated here through December 1996 was about 300 ML; 4.6 kg of VOCs were removed from the water. The treated ground water was discharged off site to the Corral Hollow Stream Channel, in accordance with WDR Order No. 91-052, NPDES Permit No. CA0082651.

Table 7-11. General Services Area ground water treatment system surface discharge effluent limitations.

Parameter	Treatment facility	
	Central General Services Area	**Eastern General Services Area**
VOCs	Halogenated and aromatic VOCs	Halogenated VOCs
Maximum daily	5.0 μg/L	5.0 μg/L
Monthly median	0.5 μg/L	0.5 μg/L
Dissolved oxygen	Maintain 5.0 mg/L minimum in receiving waters	Maintain 5.0 mg/L minimum in receiving waters
pH	Between 6.5 and 8.5, no receiving water alteration greater than ±0.5 units	Between 6.5 and 8.5, no receiving water alteration greater than ±0.5 units
Temperature	No alteration of ambient receiving water conditions more than 3°C	No alteration of ambient receiving water conditions more than 3°C
Place of discharge	Surface water drainage course in eastern GSA canyon	Corral Hollow Creek
Flow rate (30-day average daily dry weather maximum discharge limit)	273,600 L	328,320 L
Mineralization	Mineralization must be controlled to no more than a reasonable increment	Mineralization must be controlled to no more than a reasonable increment
Methods and detection limits for VOCs	EPA Method 601—method detection limit of 0.5 μg/L EPA Method 602—method detection limit of 0.3 μg/L	EPA Method 601—method detection limit of 0.5 μg/L

During 1996, the air sparging treatment system used to treat ground water in the eastern GSA was replaced by aqueous-phase carbon adsorption treatment units. The aqueous-phase carbon adsorption units are less complex in both design and operation than air sparging technology and will incur lower operation and maintenance costs. Before cleanup was initiated, the portion of the plume with TCE concentrations in excess of the MCL (5 μg/L) extended about 1400 m off site; it now extends only 60 m off site. LLNL estimates that 9 more years of ground water extraction and treatment will be required to achieve and maintain ground water VOC concentrations below MCLs at the eastern GSA.

The two VOC ground water plumes in the central GSA are present in alluvium and shallow bedrock and in deeper bedrock. Construction of an air-sparging ground water treatment system and vapor extraction and treatment unit for a CERCLA Removal Action to remove VOCs from the central GSA ground water and soil vapor was completed in 1993. During 1993, ground water extraction and treatment began. From 1993 through the end of 1996, about 2.6 ML of ground water containing 4.5 kg of VOCs was treated. The treated ground water was collected and batch discharged in a remote

Site 300 canyon, in accordance with the Substantive Requirement for wastewater discharge. Following dewatering of bedrock through ground water extraction, soil vapor extraction and treatment of VOCs began in 1994. From 1994 through the end of 1996, soil vapor was treated with carbon adsorption to remove 29.6 kg of VOCs. By 1996, VOC concentrations in soil vapor pumped from the central GSA soil vapor extraction (SVE) wells had been reduced from a historical high of 450 ppm to less than 5 ppm (based on volume). Because VOC concentrations had been level at about 2 ppm for approximately one year, the SVE system was shut off to determine if VOC concentrations in soil vapor would increase or "rebound" during the shutdown period.

LLNL estimates that an additional 9 years of soil vapor extraction and 54 years of ground water extraction are required to achieve and maintain ground water VOC concentrations below MCLs at the central GSA.

The *Draft Final and Final Proposed Plan for the General Services Area Operable Unit* (LLNL 1996b and c) were submitted to the regulatory agencies on February 15 and March 15, 1996, respectively, and describe the proposed remedial strategies for public evaluation. A Public Meeting was held on April 24, 1996, to provide a forum for public comment on the proposed remedial strategy (continued pump-and-treat) for the General Services Area operable unit. The *Draft and Draft Final Records of Decision for the General Services Area Operable Unit* (LLNL, 1996d and e) were submitted to the regulatory agencies on July 19 and December 1, 1996, respectively, and document the agreed remedial action.

Cooling Towers

LLNL samples cooling-tower wastewater discharges as required by the Self-Monitoring Program of WDR 94-131, NPDES permit CA0081396, and reports the results of the compliance sampling to the Central Valley Regional Water Quality Control Board (CVRWQCB) quarterly.

The cooling towers, used to cool buildings and equipment at Site 300, discharge noncontact cooling water to man-made and natural drainage courses (**Figure 7-17**). These drainage courses flow into Corral Hollow Creek, a tributary of the San Joaquin River.

WDR 94-131 establishes effluent limits for three parameters: (1) daily flow must not exceed the maximum design flow; (2) total dissolved solids (TDS) must not exceed a monthly average of 2000 mg/L or a maximum daily limitation of 2400 mg/L; and (3) pH must not exceed 10. Along with effluent monitoring, when Corral Hollow Creek is flowing, the permit requires LLNL to collect pH samples upstream and downstream of

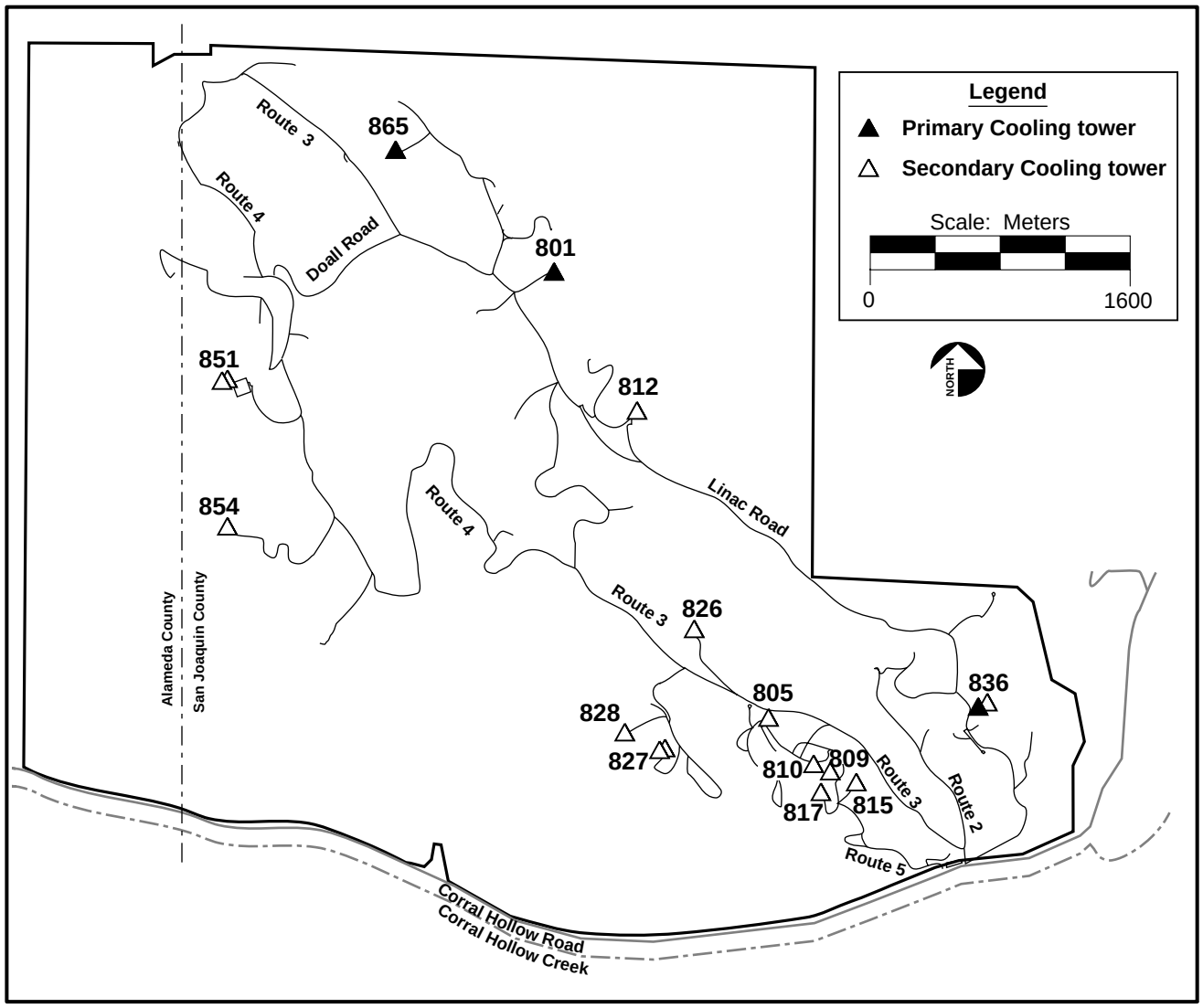

Figure 7-17. Site 300 cooling tower locations, 1996.

the cooling tower discharge points into the creek and to conduct visual observations of the creek. Cooling tower discharges must not raise the pH of Corral Hollow Creek above 8.5 or alter the ambient pH by more than 0.5.

Two cooling towers, located at Buildings 801 and 836A, regularly discharge to surface water drainage courses. Fourteen other cooling towers routinely discharge to percolation pits under a waiver of waste discharge requirements from the Central Valley RWQCB. The permit establishes separate effluent limits for these 14 towers (dissolved solids must not exceed a monthly average of 2000 mg/L or 5000 mg/L daily; pH must not exceed 10) in the event that discharge to surface water drainage courses is necessary,

such as during maintenance of the percolation pits. One such discharge occurred in June of 1996 when flow from the Building 812 cooling tower was diverted to the storm water drainage course for maintenance of the percolation pit. Flow returned to the percolation pit by July 1996. The Central Valley RWQCB was notified in May of 1996, and sample results of 920 mg/L TDS and 8.6 pH demonstrated compliance with the permitted limits.

In August 1995, the cooling tower at Building 865 was taken off line. To preserve the tower for future use, components of the wooden tower were kept wet with the use of a sprinkler system to prevent the loss of structural integrity. LLNL informed the Central Valley RWQCB of the change in the tower status and continued to monitor the sprinkler water discharge according to the requirements of WDR 94-131 until August 1996, when the facility decided to decommission the tower and discontinued the use of the sprinkler system.

Monitoring results demonstrate that all cooling tower discharges were in compliance with all permitted limits, with the exception of one event in July, when the Building 801 tower exceeded its maximum permitted design flow by 155 L. Subsequent sampling events demonstrated that the flow was once again below the limit. Occasional slight exceedances of the maximum permitted design flow are expected for this tower during the hottest months when evaporation is also highest; this is noted in Attachment B of the WDR 94-131.

Monitoring results are detailed in the quarterly reports to the Central Valley RWQCB and are summarized in **Table 7-12** (compliance data) and **Table 7-13** (operational data). LLNL reports operational values at the request of the Central Valley RWQCB, but they are not used to determine compliance. All pH samples collected from the cooling tower discharges were below the permitted maximum of 10. TDS concentrations are consistently below both the daily maximum and monthly average limits. During the 1996 reporting period, there was no continuous flow in Corral Hollow Creek; therefore no monitoring was required.

Other Waters

Additional surface water monitoring is driven by DOE Orders 5400.1, General Environmental Protection Program, and 5400.5, Radiation Protection of the Public and the Environment. Surface and drinking water near the Livermore site and in the Livermore Valley are sampled at locations shown in **Figure 7-18** according to procedures set out in Appendix A of the *Environmental Monitoring Plan* (Tate et al. 1995). Sampling

locations DEL, ZON7, DUCK, ALAG, SHAD, and CAL are surface water sources; BELL, GAS, PALM, and ORCH are drinking water outlets. LLNL samples these locations for gross alpha, gross beta, and tritium. In the past, LLNL sampled these locations quarterly. Because past monitoring has consistently showed background levels of these constituents, samples were taken semiannually in 1996. The on-site swimming pool and drinking water sources POOL and TAP were also sampled, as described above, for gross alpha, gross beta, and tritium. POOL is sampled monthly, TAP quarterly.

Table 7-12. Summary data from compliance monitoring of Site 300 primary cooling towers, 1996.

Test	Tower no.	Minimum	Maximum	Median	Interquartile range	Number of samples
Total dissolved solids (mg/L)[a]	801	920	1400	1300	—[f]	4
	836A	1200	1300	1300	—[f]	4
	865	670	1300	730	—[f]	3
Flow (L/day)	801[b]	0	16,430	3139	5955	26
	836A[c]	0	2511	1010	1948	25
	865[d]	0	332	0.34	33	16
pH[e]	801	8.5	9.2	8.7	—[f]	4
	836A	8.5	8.7	8.6	—[f]	4
	865	7.9	8.7	8.2	—[f]	3

a Maximum permitted total dissolved solids = 2400 mg/L.

b Maximum permitted design flow = 16,276 L/day.

c Maximum permitted design flow = 8138 L/day.

d Maximum permitted design flow = 90,840 L/day.

e Maximum permitted pH = 10.

f Not enough data points to determine.

Table 7-13. Summary data from operational monitoring of Site 300 primary cooling towers, 1996.

Test	Tower no.	Minimum	Maximum	Median	Interquartile range	Number of samples
Total dissolved solids (mg/L)[a]	801	900	1450	1350	100	26
	836A	1050	1300	1200	50	26
pH[b]	801	8.7	9.0	8.9	0.1	26
	836A	8.6	9.1	8.8	0.2	26

a Maximum permitted total dissolved solids = 2400 mg/L.

b Maximum permitted pH = 10.

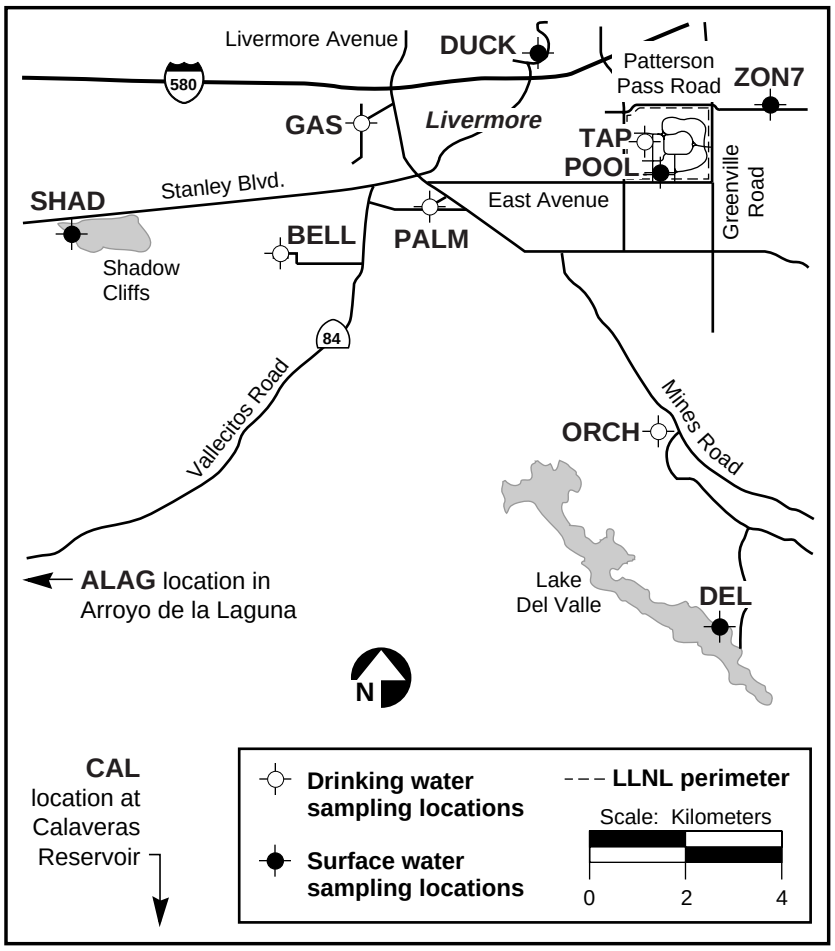

Figure 7-18. Surface and drinking water sampling locations, Livermore Valley, 1996.

Median activities for gross alpha and gross beta radiation in surface water samples are generally less than 10% of the drinking water maximum contaminant levels (MCLs). However, maximum activities detected for gross alpha and gross beta (both from location ORCH) were 0.43 Bq/L (11.6 pCi/L) and 0.74 Bq/L (20 pCi/L), or 77% and 40% of their respective MCLs (see **Table 7-14**). Detailed data are in Volume 2, Table 7-8. Historically, gross alpha and gross beta radiation has fluctuated about the laboratory detection limits. At these very low levels, the error measurements are nearly equal to the measured values so that no trends are apparent in the data.

Table 7-14. Radioactivity (in Bq/L) in surface and drinking water in the Livermore Valley, 1996.

Location	Tritium	Gross alpha	Gross beta
Median	2.24	0.050	0.088
Minimum	1.62	0	0.
Maximum	5.51	0.43	0.74
Interquartile range	0.89	0.045954	0.14874
Maximum contaminant level (MCL)	740	0.56	1.85

Environmental Impacts

With the exception of one event in July, when the Building 801 cooling tower slightly exceeded its design flow, all Site 300 cooling towers that discharge to surface were within their permitted flow limits. All cooling tower discharges were in compliance with permitted limits for pH and TDS. All discharges from treatment facilities that discharge to surface were within their compliance limits. Thus, data indicate no impact to surface waters from LLNL Livermore site and Site 300 cooling towers and treatment facilities.

There is no evidence of adverse environmental impact resulting from releases from the Drainage Retention Basin. Though internal measurements indicated that concentrations were above the management action levels for several constituents, only iron was discharged above amended limits established to protect receiving waters. In April 1997, the discharge limits established under CERCLA were again amended by the Remedial Project Managers, and the iron limit was determined to be not applicable and was completely dropped as a discharge limit because it had no aquatic life or human health protection water quality criteria.

Preliminary indications are that concentrations of some metals in storm water may be increasing; these levels may be related to suspended solids in the storm water. Further evaluation of the source of these metals has been planned. During the next wet season (1997-98), analysis will be conducted for both dissolved and total metals in both NPDES-driven (compliance) and DOE-order driven (surveillance) sampling. Although some 1996 storm water results were above criteria, there is no evidence that indicates any impact to off-site biota, and the acute fish toxicity test further supports the conclusion that LLNL storm water has no adverse effect on off-site biota.

The environmental impact of tritium measured in rainfall samples from the Livermore site was negligible. The highest tritium activity measured in 1995 rainfall was 170 Bq/L (4590 pCi/L), about 23% of the MCL for tritium (740 Bq/L). Tritium activities measured in Livermore site and Livermore Valley surface and drinking water were even lower, with a maximum of 5.51 Bq/L (149 pCi/L), or about 0.7% of the MCL. Maximum activities for gross alpha and gross beta in Livermore site and Livermore Valley surface and drinking water were also below MCLs. The maximum activities for gross alpha and gross beta were 0.43 Bq/L (11.6 pCi/L) and 0.74 Bq/L (210 pCi/L), or 77% and 40% of their respective MCLs.

LLNL maintains an extensive monitoring network for surface water, which includes treatment facility and cooling tower discharges, rain water, storm water, and both on-site and off-site drinking water and surface water. The sample data indicate that the impact of LLNL Livermore site and Site 300 operations on off-site surface water is negligible.